Dissertation on

A STUDY OF VARIATIONS OF ANTERIOR CEREBRAL ARTERY AND ANTERIOR COMMUNICATING ARTERY

Submitted in partial fulfillment for

M.D DEGREE EXAMINATION

BRANCH-XXIII ANATOMY

Upgraded Institute of Anatomy
Madras Medical College & Rajiv Gandhi Government Hospital,
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THE TAMILNADU Dr.M.G.R. MEDICAL UNIVERSITY
CHENNAI – 600 032
TAMILNADU

MAY 2019

CERTIFICATE

This is to certify that this dissertation entitled **"A STUDY OF VARIATIONS OF ANTERIOR CEREBRAL ARTERY AND ANTERIOR COMMUNICATING ARTERY"** is a bonafide record of the research work done by **Dr. P. SOUNDARYA,** Post graduate in the Institute of Anatomy, Madras Medical College and Research Institute, Government General Hospital,Chennai-03, in partial fulfillment of the regulations laid down by The Tamil Nadu Dr.M.G.R. Medical University for the award of **M.D.** Degree Branch XXIII - Anatomy, under my guidance and supervision during the academic year from 2016-2019.

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CERTIFICATE OF APPROVAL

To
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Dear Dr.P.Soundarya ,

The Institutional Ethics Committee has considered your request and approved your study titled **"A STUDY OF VARIATIONS OF ANTERIOR CEREBRAL ARTERY AND ANTERIOR COMMUNICATING ARTERY " - NO.20012017 (IV).**

The following members of Ethics Committee were present in the meeting hold on **31.01.2017** conducted at Madras Medical College, Chennai 3

1.Dr.C.Rajendran, MD.,	:Chairperson
2.Dr.M.K.Muralidharan,MS.,M.Ch.,Dean, MMC,Ch-3	:Deputy Chairperson
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8.Tmt.J.Rajalakshmi, JAO,MMC, Ch-3	: Lay Person
9.Tmt.Arnold Saulina, MA.,MSW.,	:Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary – Ethics Committee

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URKUND

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52

PLAGIARISM CERIFICATE

This is to certify that this dissertation work titled **"A STUDY OF VARIATIONS OF ANTERIOR CEREBRAL ARTERY AND ANTERIOR COMMUNICATING ARTERY"** of the candidate **DR. P. SOUNDARYA** with registration Number **201633004** for the award of **M.D** in the branch of **ANATOMY**. I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **9% percentage** of plagiarism in the dissertation.

Guide & Supervisor sign with Seal.

LEGEND

ACA	-	Anterior Cerebral Artery
ACoA	-	Anterior Communicating Artery
ICA	-	Internal Carotid Artery
RAH	-	Recurrent Artery of Heubner
CMA	-	Calloso Marginal Artery
OFA	-	Orbito Frontal Artery
FPA	-	Fronto Polar Artery
OP.N	-	Optic Nerve
OP.C	-	Optic Chiasma

CONTENTS

Introduction

INTRODUCTION

It is important to emphasize the anomalies of the cerebral circulation, as they are not rare and may have profound clinical implications. Anterior Cerebral Artery (ACA) contributes to the major part of anterior circulation of human brain by completing the anterior component of Circle of Willis along with the Anterior Communicating Artery (ACoA). Variations in anterior circulation of the brain is important in Neuro surgical Interventions particularly related to aneurysms and craniotomies.

Anterior Cerebral Artery (ACA) is one of the terminal branches of Internal Carotid Artery (ICA). It starts at the medial end of the stem of lateral fissure, passes anteromedially above the optic nerve to the great longitudinal fissure. The Anterior Cerebral Arteries of both sides travel together in the great longitudinal fissure, connected by a short transverse ACoA. The ACA passes around the curve of the genu of corpus callosum and then along its upper surface till its posterior end, where it anastomoses with the Posterior Cerebral Artery.

ACA is usually smaller than the Middle Cerebral Artery (MCA), although it may be larger than the MCA especially if the contralateral A1 is aplastic or very hypoplastic. Sometimes it may be equal in size to the MCA. As the ACA leaves the ICA bifurcation, it is crossed by thickened bands of arachnoid coursing from the olfactory trigone to the lateral part of the optic nerve and forming a tunnel through which the artery enters the lamina terminalis cistern.

The exact course of the artery is variable as it may loop underneath the orbitofrontal lobe so its junction with the ACoA may be quite anterior.

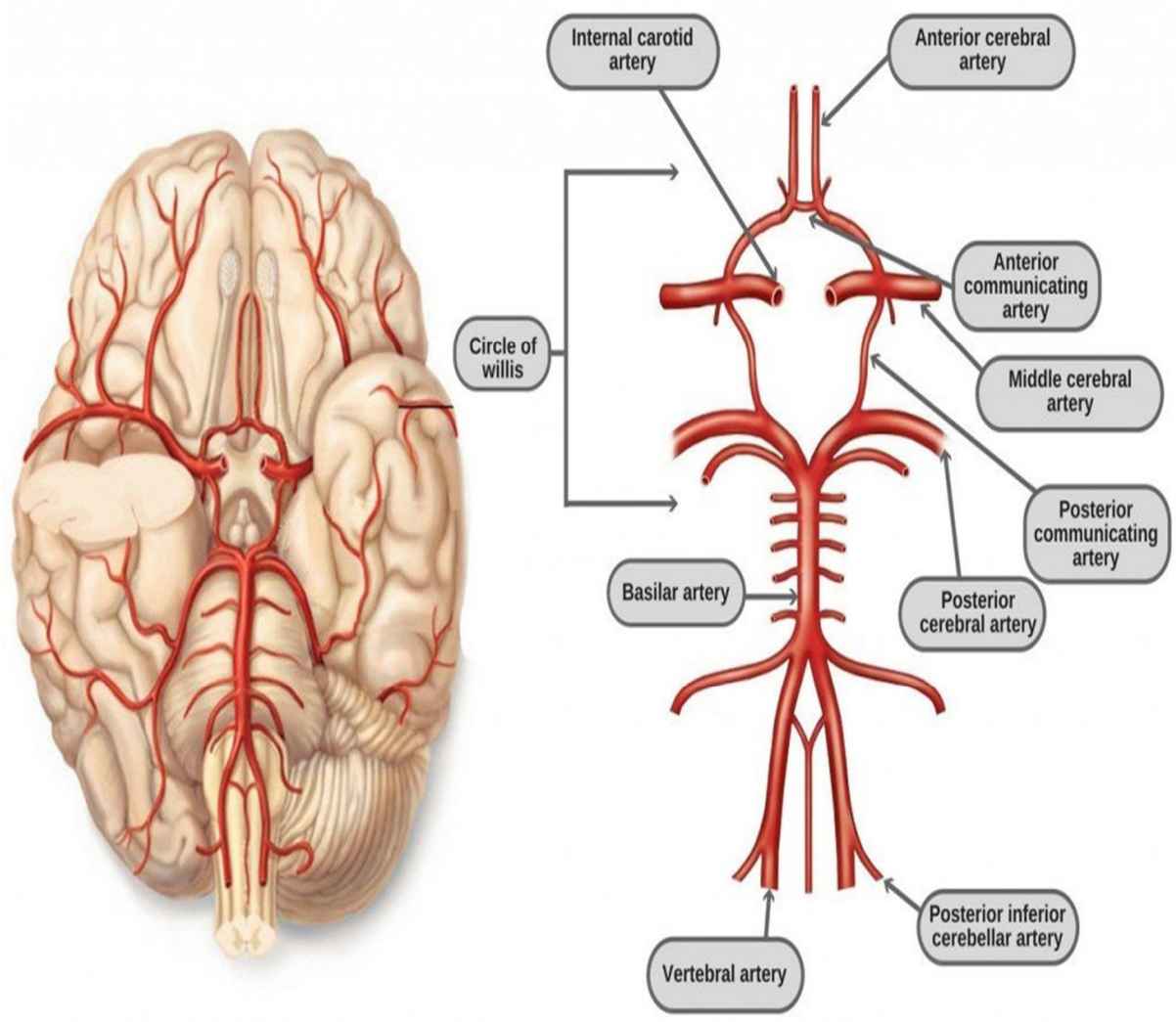


Fig: Circle of Willis

Anterior cerebral arteries give cortical and central branches. The major cortical branches are Orbito Frontal Artery, Fronto Polar Artery, Calloso Marginal Artery (CMA) and Pericallosal artery. The major central branch is recurrent artery of Heubner (medial striate artery). The cortical branches supply motor and somatosensory cortices which represent the lower limb. The central branches arise from its proximal portion and enter the anterior perforated substance and lamina terminalis collectively. The central branches supply the rostrum of corpus callosum, the septum pellucidum, the anterior part of putamen, the head of caudate nucleus and adjacent parts of internal capsule. The medial striate artery supplies the anterior part of head of caudate nucleus and adjacent regions of the putamen and internal capsule.

The surgical nomenclature divides the ACA into three parts [58]

A1 - from the termination of Internal Carotid Artery to the junction of ACA and Anterior Communicating Artery

A2 - from the junction with Anterior Communicating Artery to the origin of the Calloso Marginal Artery

A3 - distal to the origin of the Calloso Marginal Artery (CMA).This segment is also known as the pericallosal artery.

Perlmutter and Rhoton divided the ACA into 5 segments:

A1 - starts at ICA termination and ends at the ACoA junction

A2 - starts at ACoA junction, follows the course of rostrum of the corpus callosum and terminates at the junction of the rostrum and genu of corpus callosum

A3 - follows the course of genu of corpus callosum and terminates where the ACA turns posteriorly above the genu

A4 & A5 - run over corpus callosum; the transition from A4 to A5 is set arbitrarily at the level of the plane defined by the coronal suture.

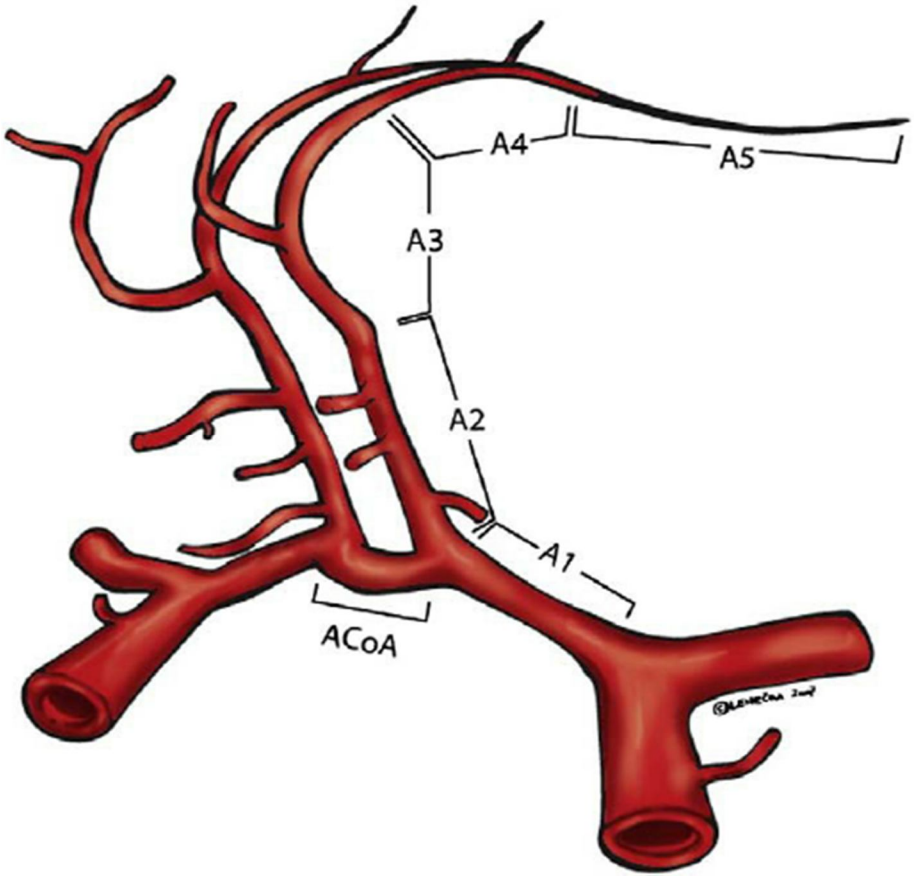


Fig: Segments of ACA

Several small perforating arteries arise along the infero posterior aspect of the proximal ACA (A1). These arteries do usually arise from 2.5 mm distal to ICA bifurcation. They are more frequent and larger in the lateral anterior cerebral area beneath the anterior perforated substance. These perforating arteries supply the septum pellucidum, the medial portion of the anterior commissure, the pillars of the fornix, the optic chiasma, the para olfactory area, the anterior limb of the internal capsule, the antero inferior part of the striatum and the anterior hypothalamus. The paired A1 segments are not always equal in diameter, the difference in diameter is more prevalent when there is ACoA aneurysms. In the presence of aneurysm of the ACoA, the base of the aneurysm arises on the side of larger A1 and the dome points towards the side of the hypoplastic A1 segment.

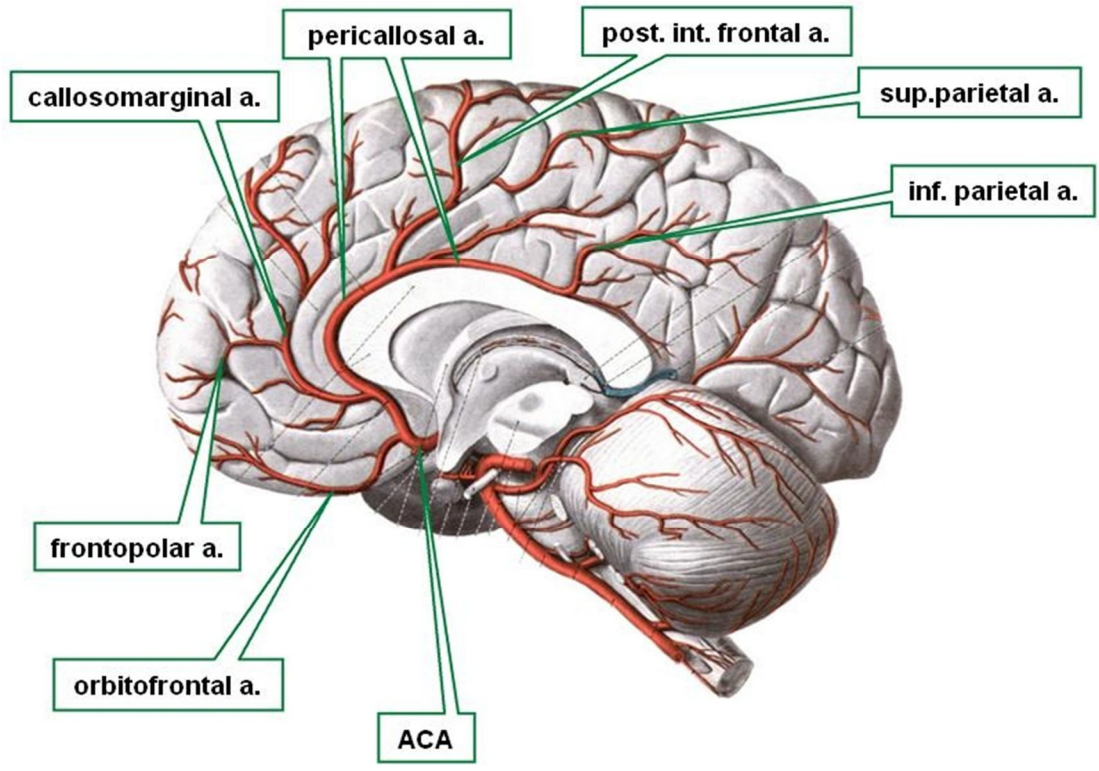


Fig : Branches of Anterior Cerebral Artery

Orbito Frontal Artery

This is the first cortical branch of distal ACA. It commonly arises from the A2 segment but may also arise as a common trunk with the fronto polar artery. It may sometimes originate from the A1 segment just proximal to ACoA. It supplies the gyrate rectus, olfactory bulb and tract and medial part of the orbital surface of the frontal lobe.

Fronto Polar Artery

It arises from the A2 segment and passes anteriorly along the medial surface of the hemisphere towards the frontal pole. It crosses the subfrontal sulcus and supplies portions of medial and lateral surfaces of the frontal pole.

Calloso Marginal Artery

The Calloso Marginal Artery runs in the cingulate sulcus. It gives off anterior, middle and posterior frontal branches which supply posterior part of the superior frontal gyrus and medial surface of the frontal lobe as far as the precentral gyrus. The Calloso Marginal Artery may terminate as Paracentral artery which supplies the upper portion of the precentral gyri and the paracentral lobule.

Recurrent artery of Heubner (Medial Striate Artery)

The most important perforator from the proximal A2 segment is the Medial Striate Artery. The length of the Heubners artery is generally twice as that of the A1 segment. Its increased length increases its exposure to injury during surgery.

It supplies the anterior striatum, a portion of the outer segment of the Globus pallidus and the anterior limb of the Internal capsule. Its injury typically results in a moderate paresis of the contralateral upper extremity and mild paresis of the contralateral face.

Anterior Communicating Artery

The Anterior Communicating Artery is a short transverse trunk that connects the left and right Anterior Cerebral Arteries. It gives off numerous anteromedial central branches which supply the optic chiasma, lamina terminalis, hypothalamus, para-olfactory areas, anterior columns of the fornix and the cingulate gyrus.

Aim of the study

AIM OF THE STUDY

The variations in the cerebral circulation are not rare and they have profound clinical implications.

Awareness of these anatomical variations are important in the exposure of brain for various purposes like skull base surgeries, carotid surgeries and cerebral angiography. The knowledge of these vascular variations increases the success rate of these procedures.

Anterior Cerebral Arteries lie lateral to optic chiasma in the angle formed by the converging optic nerves, the chiasma or the optic tracts. In such individuals pressure from the arteries may produce various defects in visual fields.

Anterior Communicating Artery is one of the components of Circle of Willis which stabilises the cerebral blood flow when the principal conduit fails. Hence knowledge on the variations in the ACoA is important in understanding the pathology of various cerebrovascular diseases and adopting effective strategies in their treatment.

The ACoA complex is adjacent to hypothalamus and cognitive emotional centres in basal frontal lobes, hence anomalies of arteries emanating from ACoA complex may affect the basalganglia, internal capsule and motor sensory cortex.

Although aneurysms may arise at any point of distal ACA and its branches, origin of Calloso Marginal artery is the most common site. The second most common site is at the origin of the Fronto Polar artery. So the measurement of distance of origin of these vessels from the Anterior Cerebral Artery and Anterior Communicating Artery junction becomes imperative.

In the presence of unequal diameters of A1segments, typically the base of the aneurysm arises on the side of larger A1 and the dome points towards the side of the hypoplastic A1. The introduction of cerebral angiography as a diagnostic technique in clinical neurology has emphasized the importance of the distribution, course and variations of individual cerebral vessel. The rapidly advancing fields of vascular neurosurgery and interventional neuroradiology require a thorough understanding of the cerebrovascular anatomy.

The variations of ACA and ACoA are studied under the following parameters.

I. Origin of Anterior Cerebral Artery

II. Relation of ACA to Optic nerve or Optic chiasma.

III. A1 segment

a) Number of A1 segment

b) Diameter of A1 segment

c) Length of A1 segment

IV. Anterior Communicating Artery

a) Number of ACoA

b) Course of ACoA

c) Length of ACoA

d) Diameter of ACoA

V. Origin of Recurrent Artery of Heubner

VI. OrbitoFrontal Artery

a) Origin of OrbitoFrontal Artery

b) Distance of origin of Orbito Frontal Artery from ACoA and ACA junction.

VII. Distance of origin of Fronto Polar Artery from ACoA and ACA junction.

VIII. Callosomarginal Artery

a) Origin

b) Distance of Calloso Marginal Artery from ACoA and ACA junction.

Review of Literature

REVIEW OF LITERATURE

I. Origin of Anterior Cerebral Artery

McClure Wilson M.D [38] (1963) has stated that the Anterior Cerebral Artery is usually the smaller of the two terminal branches of the Internal Carotid Artery.

W. Henry Hollinshead [63] (1968) has stated that the Internal Carotid Artery curves upwards and backwards to divide into its two terminal branches, the small Anterior Cerebral Artery and large Middle Cerebral Artery, approximately lateral to optic chiasma.

Malcolm B. Carpenter [34] (1969) has stated that, lateral to optic chiasma the Internal Carotid Artery divides in to two terminal branches, the smaller Anterior Cerebral Artery and the larger Middle Cerebral Artery.

John V. Basmajian [22] (1980) has stated that the Internal Carotid Artery ends as the Anterior and Middle Cerebral Arteries.

G.J.Romanes [17] (1986) has stated the Internal Carotid Artery passes in to a shallow pit immediately inferior to the anterior perforated substance. Here the artery divides in to the Anterior and Middle Cerebral Arteries.

Anne G. Osborn [4] (1994) has stated that the ACA is the smaller of the two terminal branches of ICA.

William W. Orrison, Jr. [64] (2000) has stated that the Anterior Cerebral Artery arises from carotid bifurcation below the perforated substance.

Saidi Hassan et al [54] (2002) found that, in the seventy two cases they dissected, the Anterior Cerebral Artery was the smaller terminal branch of the Internal Carotid Artery.

Eric H. Sincoff et al [13] (2003) reported a case of anomalous origin of the left ACA segment from the right ICA.

Susan Standring [58] (2005) has stated that Anterior Cerebral Artery is the smaller of the two terminal branches of the Internal Carotid Artery.

Richard S. Snell [49] (2006) has stated that the Anterior Cerebral Artery is the smaller terminal branch of Internal Carotid Artery.

Sandhya Arvind Gunnal et al [55] (2013) has observed that Anterior Cerebral Artery is an important terminal branch of Internal Carotid Artery.

Rishi Pokhrel et al [51] (2013) has reported an anomalous origin of both left and right Anterior Cerebral Arteries from right Internal Carotid Artery.

Keith L. Moore and Arthur F. Dalley [26] (2014) has stated that the terminal branches of Internal Carotid Artery are the Anterior and Middle cerebral Arteries.

Smita B.Shinde et al [56] (2016) has observed that Anterior Cerebral Artery is one of the terminal branches of Internal Carotid Artery below the anterior perforated substance.

Tripathi A.,et al [61] (2017) has observed that Anterior Cerebral Artery starts at the medial end of the lateral cerebral sulcus, as the smaller terminal branch of the Internal Carotid Artery, the larger one being Middle Cerebral Artery.

Mahajan A et al [33] (2018) has reported an anomalous origin of left Anterior Cerebral Artery from the contralateral Internal Carotid Artery associated with hypoplastic right Anterior Cerebral Artery.

II. Relation of ACA to Optic nerve or Optic chiasma

W. Henry Hollinshead [63] (1968) has stated that the Anterior Cerebral Arteries pass forward and medially above the Optic nerves, chiasma or tracts to the longitudinal cerebral fissure.

W. J. Hamilton [62] (1976) has stated that ACA runs forward & medially above the optic nerve to the longitudinal fissure.

GJ Romanes [17] (1986) has stated that ACA runs horizontally in an anteromedial direction to the longitudinal fissure where it is joined to the opposite ACA by the short Anterior Communicating Artery, anterosuperior to the Optic chiasma.

Randy Jinkins. J [48] (2000) has stated, that rarely the Anterior Cerebral artery arises from the intradural ICA near the origin of Ophthalmic artery. In such cases, it passes inferior to the optic nerve and then ascends in front of the optic chiasma.

William W. Orrison, Jr. [64] (2000) has stated that the proximal or horizontal segment of the ACA is known as the A1 segment, which courses anteriorly and medially over the optic nerve and chiasma to the interhemispheric fissure.

SusanStandring [8] (2005) has stated that the Anterior Cerebral Artery passes anteromedially above optic nerve to the great longitudinal fissure.

SB Pai et al [42] (2005) observed that the ACA courses anteromedially to cross the optic nerve and optic chiasma to communicate with opposite ACA through ACoA.

Henry H. Schmidek [20] (2006) has stated that the A1 segment courses medially and anteriorly over the optic tract and chiasma to the Anterior Communicating Artery complex.

Richard S. Snell [49](2006) has stated that the ACA runs forward and medially superior to the optic nerve and enters the longitudinal fissure of the cerebrum.

J.Peltier et al [44] (2007) reported that in a 61 year old female individual, on both sides the precommunicating parts of the Anterior Cerebral Artery were found to course inferior to the ipsilateral optic nerves.

MasatouKawashima [36] (2009) has stated that the A1 courses above the optic chiasma or nerves to join the ACoA. The junction of the ACoA with the right and left A1 is usually above the chiasma (70% of brains) rather than above the optic nerves (30%). Of the arteries traversing above the optic nerves, most traverse above the nerve near the chiasma rather than distally.

CessyJob et al [9] (2016) observed that the right Anterior Cerebral Artery has a chiasmal relation while the left crosses well in advance of the chiasma.

III. A1 segment of the Anterior Cerebral Artery.

a) Number of A1 segment

Michael L.J. Apuzzo [39] (1993) has stated that A1 segment of one side may be absent or extremely hypoplastic. He also added that rarely the A1 segment may be duplicated or fenestrated.

Anne G. Osborn [4] (1994) has stated that hypoplastic or absent A1 segment is seen in 5% to 18% of all cases.

Piganiol et al [46] (1960) has observed agenesis of A1 segment in his study in 2.1% of the specimens.

Randy Jinkins. J [48] (2000) has stated that the A1 segment of the Anterior Cerebral Artery may be hypoplastic or absent in upto 10% of cases. In both instances the A1 segment of the contralateral Anterior Cerebral Artery joins the

ACA distal to the hypoplastic or absent segment via the Anterior Communicating Artery.

Richard Winn. H [50] (2004) has stated that the duplication of the A1 segment (2%) is a rare but surgically important anatomic variant which occurs only unilaterally.

Sandhya Aravind Gunnal et al [55] (2013) Out of 112 formain fixed brains in her study on Variations of Anterior Cerebral Artery in human cadavers, she has observed two cases (1.8%) of the agenesis of A1 segment. she also noted duplication of the A1 segment in one (1.1%) of her cases. She has also mentioned underdeveloped A1 segment was seen in 9 cases (8.0%).

Yuhui Cui et al [65] (2015) observed the absence of A1 segment in one cerebral hemisphere (2.2%) out of 90 cerebral hemispheres, where the A2 segment of both sides merely originated from the A1 segment in the left side..

Cessy Job et al [9] (2016) observed absence of A1 segment in one case and also observed partial duplication in two cases out of the 104 brain specimens studied.

M Janardhan Rao et al [32] (2017) observed triplication of A1 segment in 2.5% of the specimens in his studies. The third artery was considered as the accessory artery which was of variable length and had almost the same diameter as both the Anterior Cerebral Arteries and was described as the Median artery of Corpus Callosum.

Shwetha Kedia et al [25] (2013) in her study on thirty cerebral hemispheres, she observed duplication of A1 segment in 3.3% of the vessels.

b) Diameter of A1

Perlmutter et al [45] (1976) has observed that the average diameter of A1 segment in his study was 2.6mm.

Lee KC et al [28] (1981) in his study observed that the diameter of the A1 segments varied from 1.45mm to 2.50mm (average 1.9mm).

Sylvia Kamath et al [59] (1981) stated that the average diameter of right A1 segment was 0.22 ± 0.06cm and left A1 segment was 0.24 ± 0.05cm. He has also observed that the maximum diameter of A1 segment on the right side was 3.9mm and on the left it was 3.6mm. The minimum diameters on the right and left sides were 0.6mm and 1.1mm respectively.

Milenkovic [40] (1985) has reported the incidence of hypoplasia of A1 segment as 9.16%.

Fredric B. Meyer [16] (1999) has stated that one A1 segment may be dominant, with the opposite A1 segment being either quite smaller in caliber or absent and also added that the average diameter of the A1 segment was 2.5mm.

Stefani MA et al [57] (2000) reported that in 76 cerebral hemispheres, the average diameter of ACA at origin was 2.61± 0.34mm.

Gholamhussain Khosravi et al [18] (2001) observed that out of 101 specimens, 6 A1 segments were hypoplastic, 4 on the left and 2 on the right side.

Richard Winn. H [50] (2004) has stated that the average diameter of A1 segment was 2.6mm. He also stated that the paired A1 segments were of equal diameter in only half of the cases. In 50% of cases, there was a difference of 0.5mm or more between the diameters of A1 segments. In 12% of cases the difference was 1mm or more. This discrepancy in diameter between the paired A1 segments was even more prevalent in cases with ACoA aneurysm, where unequal diameter was present in 25% of cases.

SB Pai et al [42] (2005) has observed that the outer diameter of the A1 segments on both sides ranged from 2.5mm to 3.5mm with a mean of 2.9mm on left side and 2.8mm on right side. He also added that the diameter of ACA was larger on the left side in 4 cases and on the right side in 2 cases. In the remaining 4 cases, the ACAs were of equal diameter on both sides. But in no situation was the difference larger than 1mm.

Henry H. Schmidek& David W.Roberts [20] (2006) has stated that asymmetry in the caliber was seen in approximately 10% of patients with a hypoplastic segment. Hypoplastic segment is defined arbitrarily as having a diameter of 1.5 mm or less. Smaller diameters are observed less frequently, with approximately 2% of patients having an A1 segment diameter of 1mm or less.

S Iqbal et al [53] (2013) has observed the incidence of hypoplasia of A1 segment in his study as 4%.

YuhuiCui et al [65] (2015) has observed in 13.3% (6/45) brain specimens, the diameter of the A1 segments significantly differed between two sides. The difference in the outer diameter was greater than 0.5mm. The diameters of A1 segments on both sides were equal in 16 specimens.

The A1 segment was absent in 1 cerebral hemisphere. In the remaining 22 hemispheres, the diameter difference of A1 segments between both sides was less than 0.5 mm.

Smitha B. Shinde et al [56] (2016) has noted that the average diameter of right A1 by dissection method was 2.1mm and the average diameter of left A1 by dissection method was 2.4mm.

M Janardhan Rao et al [32] (2017) observed the incidence of the hypoplasia of A1 segment in 5 % of his study specimens.

c) Length of A1 segment

Lee KC et al [28] (1981) has observed that A1 segments varied in length from 1.34cm to 1.90cm, with an average of 1.53 cm.

Sylvia Kamath et al [59] (1981) observed that the average length of right A1 segment was 1.47 ± 0.30cm and left A1 segment was 1.38 ± 0.27cm. In his study he has observed that the greatest length measured for Anterior Cerebral Artery

was 2.10 cm on the right side and 2.56 cm on the left side. The smallest length measured for Anterior Cerebral Artery was 0.06 cm on the right side and 0.11cm on the left side.

Stefani MA et al [57] (2000) have observed that, on examining 76 cerebral hemispheres, the average distance between the origin of ACA and ACoA was 7.68 ± 3.91mm.

Richard Winn. H [50] (2004) has stated that the average length of the A1 segment was 12.7mm.

SB Pai et al [42] (2005) has stated that the length of A1 ranged from 10mm to 19 mm with a mean of 14.5mm on left side and 14.6mm on right side.

Masatou Kawashima et al [36] (2009) observed that the length of A1 varies from 7.2mm to 18.0 mm (average - 12.7 mm).

Sandhya Arvind Gunnal et al [55] (2013) in her study on 112 cerebral hemispheres, observed that the average length of A1 segment was 15.7mm. The greatest length of A1 segment measured was 25mm and the least is 11mm.

Smita B. Shinde et al [56] (2016) in their study observed that on the right side, the maximum length of the A1 segment observed was 1.5cm and the minimum length observed was 1.1 cm. The mean length of the A1 segment observed on the right side was 1.3cm. On the left side, the maximum length of the A1 segment observed

was 1.3cm and the minimum length observed was 1.1cm. The mean length of the A1 segment observed on the left side was 1.20cm.

Cessy job et al [9] (2016) have observed that the greatest length measured for the A1 segment of ACA in their study was 1.9cm and the smallest was 0.5 cm.

Yuhui Cui et al [65] (2015) have observed that the length of A1 segment was equal in 20 specimens, a difference of 1mm in length was observed in 8 specimens, 2mm in 6, and more than 3mm in 10.

IV. Anterior Communicating Artery

a) Number of ACoA

W. Henry Hollinshed [63] (1968) has quoted that Anterior Communicating Artery is rarely absent; occasionally it is double (7 to 9 percent) or even triple. It is absent when there is fusion between the two anterior cerebral arteries.

Kwak R et al [27] (1980) has noted the duplication of ACoAs in 17 of his study cases (5.7%)

Lee KC et al [28] (1981) observed that among 10 Anterior Communicating Arteries examined, double Anterior Communicating Artery was found in 2 cases and triple in one case.

Anne G. Osborn [4] (1994) has stated that duplicated ACoA occur in 10% of all cases.

William W. Orrison, Jr [64] (2000) mentioned that two or more anterior communicating arteries may be seen in 11% to 43% of brains.

Gholamhussain Khosravi [18] (2001) has observed that out of 101 brain specimens he studied, 18 ACoAs were duplicated.

Saidi Hassan et al [54] (2002) in his study on thirty six cadaveric brains, has reported that complete duplication of the anterior communicating artery was seen in 14% of the specimens.

Richard Winn. H [50] (2004) has stated that two ACoAs were present in 30% of cases and three ACoAs were present in 10% of cases. Absence of the ACoA was exceedingly rare (only 0.2% of cases).

EsraGurdal et al [14] (2004) reported a case of duplication of the ACoA associated with fenestration of the right ACA in one specimen in his cadaveric study on 30 specimens.

S B Pai et al [42] (2005) has stated that in two out of ten cases, there was duplication of the ACoA which included one which was thin and rudimentary. The other better formed duplication of the ACoA gave origin to a perforator.

Henry H. Schmidek and David W. Roberts [20] (2006) stated that the ACoA can be duplicated in one third of patients and triplicated in 10%of patients, but it is always present.

Kapoor K et al [24] (2008) mentioned that the Anterior Communicating Artery was absent in 1.8%, duplicate in 10%, triplicate in 1.2% and plexiform in 0.4% of his study specimens.

AtthapornBoongird et al [6] (2009) observed that out of the fifty specimens he studied, 41 specimens had single ACoA. Multiple ACoA were found in nine cases (18%), which included eight cases of double ACoA and one triple ACoA.

Sandhya Arvind Gunnal et al [55] (2013) observed that out of 112 brains, double ACoA were seen in 11 cases (9.8%)

PoorwaBaburaoKardile et al [47] (2013) in his study on 100 human brains, observed duplication of Anterior Communicating Artery in 10 specimens. Anterior Communicating Artery was absent in 8 specimens. He also observed triplication of Anterior Communicating Artery in 1 specimen.

Rishi Pokhrel et al [51] (2013) during routine dissection found that in one case ACoA was absent and right and left anterior cerebral arteries arose from right internal carotid artey, which was slightly larger than the left internal carotid artery.

Yuhui Cui et al [65] (2015) in his study on 45 formalin preserved brains, observed single ACoA in 17 specimens, double ACoA in 25 specimens, and triple ACoA in three specimens. The ACoA was absent in one brain specimen.

M Janardhan Rao et al [32] (2017) observed the duplication of ACoA in 7.5% of the study specimens.

Ajay BabuKannabathula et al [1] (2017) noted a complete heptagonal form of circle of willis with duplication of the Anterior Communicating Artery in 5 out of 75 specimens.

He has also documented complete heptagonal form of circle of willis with triplication of anterior communicating artery in one specimen. Complete hepatagonal form with absence of Anterior Communicating artery was found in two of his study specimens.

b) Course of ACoA

Parsons Schaeffer [43] (1953) has stated that the Anterior Communicating Artery was a transverse trunk that connects the two Anterior Cerebral Arteries.

Ronald A [52] (1995) has stated that ACoA may not be oriented in a strictly transverse plane. It can be oriented in an oblique or antero-posterior plane, if one ACA passes between the hemispheres behind the other, as occurs in 80% of brains. It may be curved, kinked or tortuous rather than straight.

Richard Winn. H [50] (2004) stated that ACoA is rarely oriented in a strictly transverse plane. At the level of ACoA junction, the left ACA courses anterior to the right in 48% of cases and the right ACA courses anterior to the left in 34% of cases. Only in 18% of cases they do enter the interhemispheric fissure side by side

and because of the course of the ACAs, the ACoA is usually oriented in an oblique or sagittal plane.

EsraGurdal et al [14] (2004) in the study on 30 cadavers, he observed two variations of ACoA, out of which one was the case where there was oblique ACoA.

SB Pai et al [42] (2005) observed that out of 10 specimens, ACoA was horizontally placed in 9 specimens and was obliquely placed in 1 specimen.

Henry H. Schmidek and David W. Roberts [20] (2006) stated that in only 18% of patients, the anterior communicating artery was oriented in the transverse plane. Instead the ACoA complex was usually rotated or tilted causing the A2 and ACoA to course obliquely in relation to one another in the interhemispheric fissure.

Shwetha Kedia et al [25] (2013) observed Anterior Communicating artery was horizontal in 2 and oblique in 13 specimens out of the fifteen specimens studied.

PoorwaBaburaoKardile et al [47] (2013) observed triplication of ACoA in one specimen, in which two arteries were parallel to each other, but the artery was obliquely placed.

Ajay BabuKannabathula et al [1] (2017) noted the complete heptagonal form of Circle of willis with duplication of ACoA in five specimens. The course of both ACoA were horizontal in one specimen. In second specimen, proximal ACoA was

horizontal and distal was oblique in course. In third specimen, proximal branch was oblique and distal branch was horizontal. In fourth and fifth specimen both were horizontal.

c) Length of ACoA

Perlmutter D, Rhoton et al [45] (1976) observed that the length of ACoA varied between 0.3 to 7.0 mm in length.

Lee KC et al [28] (1981) observed the length of the Anterior Communicating Artery between 1.0mm to 3.4mm (average 1.73mm).

Sylvia Kamath et al [59] (1981) observed that the average length of ACoA was 0.25 ± 0.18cm. The maximum length of ACoA observed in his study was 1.04 cm and the minimum length observed was 0.05 cm

Ronald A [52] (1995) has stated that the ACoA is usually between 2mm and 3mm in length, but may vary from 0.3mm to 7mm.

Fredric B. Meyer [16] (1999) has stated that the Anterior Communicating Artery is 0.1mm to 3.0mm long.

Susan Standring [58] (2005) has stated that the Anterior Communicating Artery is 0.4mm in length.

SB Pai et al [42] (2005) observed that the average length of ACoA in his study was 2.5mm**.**

Sandhya Arvind Gunnal et al [55] (2013) has observed that the average length of ACoA in her study was 3.3mm. She has also observed that the maximum length of ACoA observed in her study was 9mm. The minimum length of ACoA observed was 1 mm.

YuhuiCui et al [65] (2015) noted that the length of ACoA ranged from 0 to 9.5mm(mean 3.34mm) in his cadaveric study.

d) Diameter of ACoA

Lee KC et al [28] (1981) observed that the anterior communicating arteries varied in diameter from 0.70mm to 1.45mm (average 1.1mm).

Sylvia Kamath et al [59] (1981) observed the average diameter of ACoA was 0.19 ± 0.09cm.

Francis Cassot et al [15] (1995) reported that the diameter of ACoA was found to vary between 0.1mm to 4.9mm with the mean value ranging from 1.5 to 1.92 mm.

Richard Winn. H [50] (2004) has stated that the average diameter of ACoA was half that of the A1 segment i.e. 1.5mm (range 0.2mm to 3.4mm).

SB Pai et al [42] (2005) noted that the diameter of the ACoA ranged from 1mm to 4mm with a mean of 2.45mm. The diameter (width) of ACoA was less than the length in 5 cases, equal to the length in one case and more than the length in remaining 5 cases.

Sandhya Arvind Gunnal et al [55] (2013) has observed that the maximum diameter of ACoA observed in her study was 4mm. The minimum diameter of the ACoA observed was 1mm. The average diameter of ACoA observed in her study was 2.4mm.

Shwetha Kedia et al [25] (2013) has noted that the diameter of ACoA varied between 1mm and 2mm in her study.

Yuhui Cui et al [65] (2015) observed that the diameter of the ACoA was between 0.2 to 3.9 mm (mean 1.22mm).

PoorwaBaburaoKardile [47] (2013) noted the presence of hypoplastic ACoA (when the diameter of ACoA is less than 1mm, it is said to be hyoplastic) in 6 cadavers.

Ajay BabuKannabathula [1] (2017) noted the presence of hypoplastic ACoA in four out of his seventy five study specimens.

V. Origin of Recurrent Artery of Heubner

Malcolm B. Carpenter [34] (1969) has stated that Recurrent Artey of Heubner arises proximal to the Anterior Communicating Artery.

Dunker and Harris [10] (1976) has described the artery as originating directly opposite to the ACoA in 90% of the 28 brains studied.

Perlmutter D Rhoton AL [45] (1976) has stated that recurrent artery of Heubner arose from A2 segment in 78% of the specimens, from A1 segment in 14 % segment and from ACoA and ACA junction in 8% of the specimens.

Lee KC et al [28] (1981) quoted that the recurrent artery of Heubner has its origin from the A2 segment of the ACA in 65%, from the A1 segment in 10%, and at the level of the Anterior Communicating Artery in 25%.

Gomes F et al [19] (1984) reported that out of the study conducted in 30 unfixed human brains (60 hemispheres), the Recurrent Artery of Heubner originated from A2 segment of ACA in 57% of specimens, from the junction of ACA & ACoA in 35% & from A1 segment of ACA in 8%.

Marinkovie's et al [35] (1986) reported that Recurrent artery of Heubner originated from the distal A2 segment of the ACA in 34% of cases, from the proximal (A1) segment of the ACA in 17%, at the level of ACoA in 21%, from the fenestration of ACA in 8% & in all the other cases (20%) from the fenestration of the Azygous ACA, accessory Middle Cerebral Artery, FrontoPolar Artery &finally by the common stem with the Orbito Frontal Artery.

Michael L.J. Apuzzo [39] (1993) has stated that the recurrent artery of Heubner arises from the lateral aspect of the ACA, usually at the level of the Anterior Communicating Artery. Its origin is from A2 segment slightly more often than from the A1 segment.

Anne G. Osborn [4] (1994) stated that the recurrent artery of Heubner was a lenticulostriate branch that typically arises from the proximal A2 segment in 50% of cases and sometimes recurrent artery of Heubner arises from A1 in 44% or less commonly, the ACoA.

Aydin IH et al [7] (1994) reported that out of 48 patients, in 58% RAH originated from the junction of A1 and A2 segment, in 23% from A2 segment of ACA & from A1 segment in 4%. It was symmetrically taking off in 13% and hypoplastic 2% of the cases.

Fredric B. Meyer [16] (1999) has stated that the RAH originates from the A2 segment in approximately 80 percent of patients and was bilateral in 95 percent. He has also added a note that the recurrent artery of Heubner occasionally originates from the frontopolar branch of the anterior cerebral artery.

Andrew H. Kaye and Peter McL. Black [3] (2000) has stated that the recurrent artery of Heubner had variable origin. In most cases (65%) it arises from the proximal A2 segment, immediately distal to the anterior communicating artery. In 25% of cases the recurrent artery of Heubner arises from the A1 segment, proximal to the anterior communicating artery. In the remaining 10% it originates at the level of anterior communicating artery.

William W. Orrison, Jr. [64] (2000) stated that the RAH may originate from either the A1 segment (14%) or proximal A2 segment (78%)**.**

GholamhussainKhosravi et al [18] (2001) observed in his study that the RAH in 101 specimens, arose on the right side from the ACA-ACoA junction (70%), A1 (15%) and A2 (15%) and on the left side from the ACA-ACoA junction (75%), A1 (20%) and A2 (5%).

Emel AVCI et al [12] (2003) observed that forty nine (64%) of the 77 RAHs arose from the A2 segment, 22 (29%) from the ACoA – ACA junction, and six (8%) from the A1 segment.

Richard Winn. H [50] (2004) stated that the Recurrent artery of Heubner arose from A2 segment in 78% of cases, from A1 segment in 14% of cases & at the level of ACoA in 8% of cases.

Susan Standring [58] (2005) stated that immediately proximal or distal to its junction with the anterior communicating artery, the ACA gives medial striate artery of Heubner.

SBPai et al [42] (2005) out of the 20 hemispheres, observed the origin of RAH from the A2 ACoA junction in 11 cases, from the proximal portion of Distal Anterior Cerebral artery in 3 cases, A1- ACoA junction in one case ,A1 segment in two cases, amd as a common origin with the medial orbito frontal branch in 2 cases. The recurrent artery of Heubner was absent in one side in one brain.

Henry H. Schmidek and David W. Roberts [20] (2006) stated that the RAH can arise from the distal A1 segment just proximal to ACoA in 14% of patients, or at the level of ACoA in 8%, but is within 4mm of ACoA in 95%.

Loukas M et al [31] (2006) reported that the origin of RAH was from the junction of ACA and ACoA in 62.3%, from proximal A2 segment of ACA in 23.3% and from A1 segment in 14.3%.

Atthaorn Boongbird et al [6] (2009) observed that A2 segment was the most common location of the Heubner`s origin and the junction of A1 and A2 was the second most common site. 91% of RAHs were demonstrated with in 2mm from proximal or distal ACoA. More over the study observed the absence of Heubner in 3 hemispheres, Double Heubners in 2 hemispheres, triple Heubners in 1 hemisphere.

ShwethaKedia et al [25] (2013) observed that Recurrent artery of Heubner arose from A2 to ACoA junction in 12, A1- ACoA junction in 2, and A1 segment in 1 cadaver. It arose as a common origin with medial orbitofrontal branch in one from A1. The point of origin was between 5mm proximally in one cadaver to 0.3mm distal to ACoA and was symmetrical in 80% cadavers.

Two separate RAHs or common branch giving rise to two RAHs were present in 8 hemispheres, 5 on the right and three on the left. Three RAHs were present in one hemisphere.

Matsuda et al [37] (2018) studied 714 RAHs from 357 brain specimens. In 76.2% of 724 arteries, the RAH originated from the junction of A1 and A2 segments, in 16.3%from A2 segment, in 7.5% it originated from the A1 segment of ACA.

VI. Orbito Frontal Artery (OFA)

a) Origin

Hong SK [21] (1997) noted an anomalous branching of the OFA from the A1 segment.

Ellie R. Lee and James D. Eastwood [11] (2000) have reported an unusual variant of the Fronto-orbital artery arising from a hypoplastic contralateral A1 segment of ACA.

William W. Orrison, Jr. [64] (2000) stated that the orbitofrontal artery was the first branch arising from the A2 segment.

Henry H. Schmidek & David W. Roberts [20] (2006) has stated that the OFA was the first cortical branch arising from the A2 segment and also added that rarely OFA and FPA can originate from a common trunk.

Atthpaorn Boongbird et al [6] (2009) observed the origin of orbito frontal artery from the A2 segment, courses to the gyrate rectus, Olfactory tract and Olfactory bulb.

Aso K et al [5] (2015) observed an unusual variant of the common trunk of the frontopolar and orbitofrontal arteries arising from the A1 segment of the Anterior Cerebral Artery associated with a ruptured aneurysm of the A1 segment.

Alin Horatiu et al [2] (2016) described a unique vascular pattern represented by two anomalous right orbito frontal arteries arising from the A2 segment of the contralateral Anterior Cerebral Artery, associated with a partially duplicated Anterior Communicating Artery.

b) Distance of OFA from ACA and ACoA junction.

Stefani MA et al [57] (2000) in his study on 76 cerebral hemispheres, observed the average distance between the origin of Orbito frontal artery and ACoA ranged from 7.68+/-3.91mm.

Emel AVCI et al [12] (2003) stated that the mean distance between ACoA and the OFA was 5.96mm and also added that OFA always arose from the A2 segment & was consistently the smallest branch and coursed to gyrus rectus, olfactory tract and olfactory bulb.

Richard Winn. H [50] (2004) has stated that the OFA originated at an average distance of 5mm (range 0 to 15mm) from ACoA junction and has an average diameter of 0.9mm (range 0.4 to 2.0mm).

Henry H.Schmidek & David W.Roberts [20] (2006) has stated that the OFA was the first cortical branch arising from the A2 segment approximately 5mm distal to ACoA.

Shwetha Kedia et al [25] (2013) observed that the average distance between the OFA and the ACoA was 4.17 mm.

VII. Fronto polar artery (FPA)

a) Distance of Fronto Polar Artery from ACA and ACoA junction.

Emel AVCI et al [12] (2003) has noted the origin of Fronto polar artery from the A2 segment in 95% of his study specimens. The remaining 5% of Frontopolar arteries arose from the A3 segment of the ACA which ran to the medial subfrontal aspect of the anterior frontal lobe. The distance between the ACoA and the origin of FPA ranged from 5.63 -18.16mm (mean 14.6mm)

Richard Winn .H [50] (2004) has stated that the Fronto polar artery arose from the A2 segment& it originates on an average of 14mm (range 2 to 30mm) from ACoA junction.

Henry H.Schmidek& David W. Roberts [20] (2006) have stated that frontopolar artery originates from A2 segment 14mm on an average from the ACoA near the genu of corpus callosum.

Shwetha Kedia et al [25] (2013) observed that the average distance between the FPA and the ACoA was 8.5mm.

VIII. Calloso Marginal Artery (CMA)

a) Origin

LemosVP et al [29] (1984) out of 52 brains studied observed unilateral absence of CMA on right side in 17.3% of the specimens and on left side in 25%.Bilateral absence was observed in 46.1% of the specimens.

Saidi Hassan et al [54] (2002) has stated that in 6 out of 72 cases (8%) the Calloso Marginal Artery was absent.

SB Pai et al [42] (2005) observed the origin of Calloso Marginal Artery from the A2 segment at the genu of the corpus callosum after which the Pericallosal artery would turn posteriorly.

Krishnamoorthy et al [60] (2006) reported a case of anomalous origin of the CMA which was associated with a saccular aneurysm from the A1 segment of the left ACA. There was associated aplasia of the right A1 segment.

Mohammad Alamgir Rana et al [41] (2014) Out of the 50 cerebral hemispheres they observed the Calloso Marginal Artery in 47 cases, out of which it arose from the pericallosal artery in 44 cases and in 3 cases it arose from the Anterior Communicating Artery.

Jun Yoshida et al [23] (2016) reported an unusual variant of Calloso Marginal Artery from the A1 segment of the left Anterior Cerebral Artery.

b) Distance of Calloso Marginal Artery from ACA and ACoA junction.

Richard Winn. H [50] (2004)has stated that the CMA originates, at an average distance of 43mm (range 12 to 47mm) from the ACA & ACoA junction & also added that it originates more proximally from A2 segment in 10% of cases and more distally in 12% of cases. He also added that CMA is absent in 18% of cases.

Cavalcanti DD et al [8] (2010) observed that the Calloso Marginal Artery was present in 93.3% of hemispheres studied and arose mainly from A3 segment (55.2%), at a mean distance of 3.11+/- 1.90 cm from the Anterior Communicating Artery.

Embryology

EMBRYOLOGY

During embryogenesis, the arteries supplying blood to the brain develop and hence variations in their anatomy may occur which may influence the development of arterial diseases. At day 24 of embryological life, the Internal Carotid Artery (ICA) is the first artery to form and it provides all the blood required by the primitive brain.

The Internal Carotid Arteries appear during the 3mm embryonic stage (24 days after fertilization) from the combination of the 3rd brachial arch arteries and the distal segments of the paired dorsal aortae. The ventral portion of the 2nd brachial arch artery disconnects from the dorsal aorta near the origin of ICA and becomes the Ventral Pharyngeal Artery. Later the Ventral Pharyngeal Artery and the ICA fuse proximally to form the Common Carotid Artery (CCA). The distal segment of the Ventral Pharyngeal Artery becomes the External Carotid Artery (ECA).

At 4mm stage, the ICA branches off in to anterior and posterior divisions. The Anterior division initially supplies the optic and olfactory regions through primitive arteries. At a later embryological stage, anterior division of the ICA gives rise to the Anterior Cerebral Artery, Middle Cerebral Artery, and the Anterior Choroidal Artery, while the posterior division gives rise to the Posterior Cerebral Artery and the Posterior Choroidal Artery.

At 40 days, the stem of the ACA elongates medially towards its counterpart. At this stage, a midline cluster of plexiform anastomoses begin to form between the adjacent and elongating ACAs. At day 44, the channels of the midline cluster of plexiform anastomoses coalesce and form one or more Anterior Communicating Arteries.

With the formation of ACoA, the adult configuration of the intracranial arteries is established.

Materials & Methods

MATERIALS AND METHODS

STUDY MATERIALS

1. 60 adult cerebral hemispheres from 21 male and 9 female cadavers.
2. Ruler and thread.
3. Digital Vernier Calipers.
4. Dissection set.

METHOD OF STUDY

1. Conventional dissection method.
2. Injection method.

SPECIMEN COLLECTION

Adult human brain hemispheres were collected from embalmed cadavers allotted for routine academic dissections to the first MBBS and first BDS students at the Institute of Anatomy, Madras Medical College, Chennai.

DISSECTION METHOD

1. Conventional dissection method:

The adult cadaver was placed in supine position. A pencil mark encircling the calvaria was made. The skull cap was removed by making a cut along this line with a saw.

To remove the brain in one piece, the falx cerebri from the crista galli was detached. Falx was pulled posteriorly. A block of wood was placed under the shoulder to allow the head to fall back, allowing the frontal lobe to move out of anterior cranial fossa. The optic nerve, internal carotid artery and infundibulum were cut. The posterior part of hemisphere was raised with fingers, pressing the Pons further posteriorly. A knife was passed into the vertebral canal in front of medulla oblongata cutting it completely from side to side. The brain was separated from cranial cavity.

Thirty whole brains were removed from cranial cavity using the above procedure. The whole brain was cut in to two equal hemispheres using the brain knife. The anterior cerebral arteries were observed on the medial surface.

The origin of Anterior Cerebral Artery was noted and its number was also noted. The course of ACA was traced and its relation to optic nerve, optic chiasma and optic tract was noted. The number of A1 segment was noted and its length was measured with thread and scale and noted. The diameter of A1 segment was measured with digital vernier calipers after injecting latex into Internal Carotid Artery and noted. Anterior Communicating Artery was observed connecting two ACA and its number, course, diameter, length were noted.

The origin of Orbito Frontal Artery was noted and its distance of origin from ACoA and ACA junction was measured. The Fronto Polar Artery was identified and its distance of origin from \][ACA and ACoA was noted. The origin of Calloso Marginal Artery and its distance from ACA and ACoA was noted in all cerebral hemispheres.

Observation

Fig. 1 a : Vessels of Anterior Cerebral Circulation
1. ICA, 2. ACA, 3. ACoA

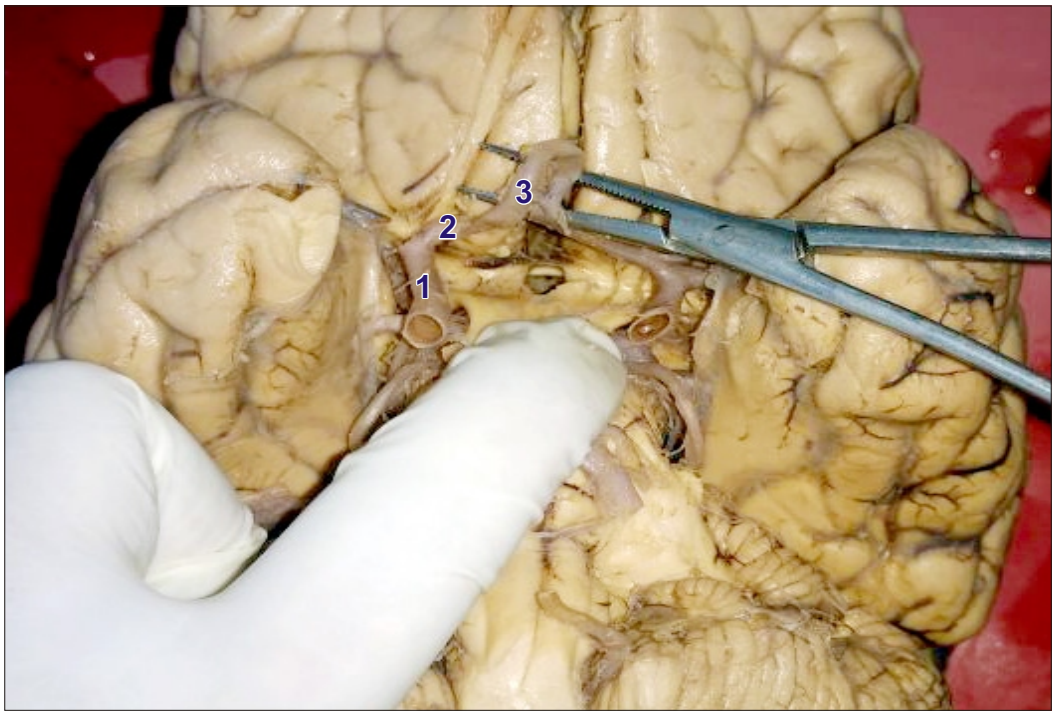


Fig. 1 b : Origin of ACA
1. ICA, 2. ACA, 3. ACoA

OBSERVATION

The Anterior Cerebral Arteries in sixty cerebral hemispheres and Anterior Communicating Arteries in thirty brain specimens were studied.

I.ORIGIN OF ANTERIOR CEREBRAL ARTERY

In the present study, the Anterior Cerebral Artery arose from the Internal Carotid Artery of the same side in all the 60 cerebral hemispheres.

There was no variation observed in the origin of ACA in the present study.

CHART 1: Origin of ACA

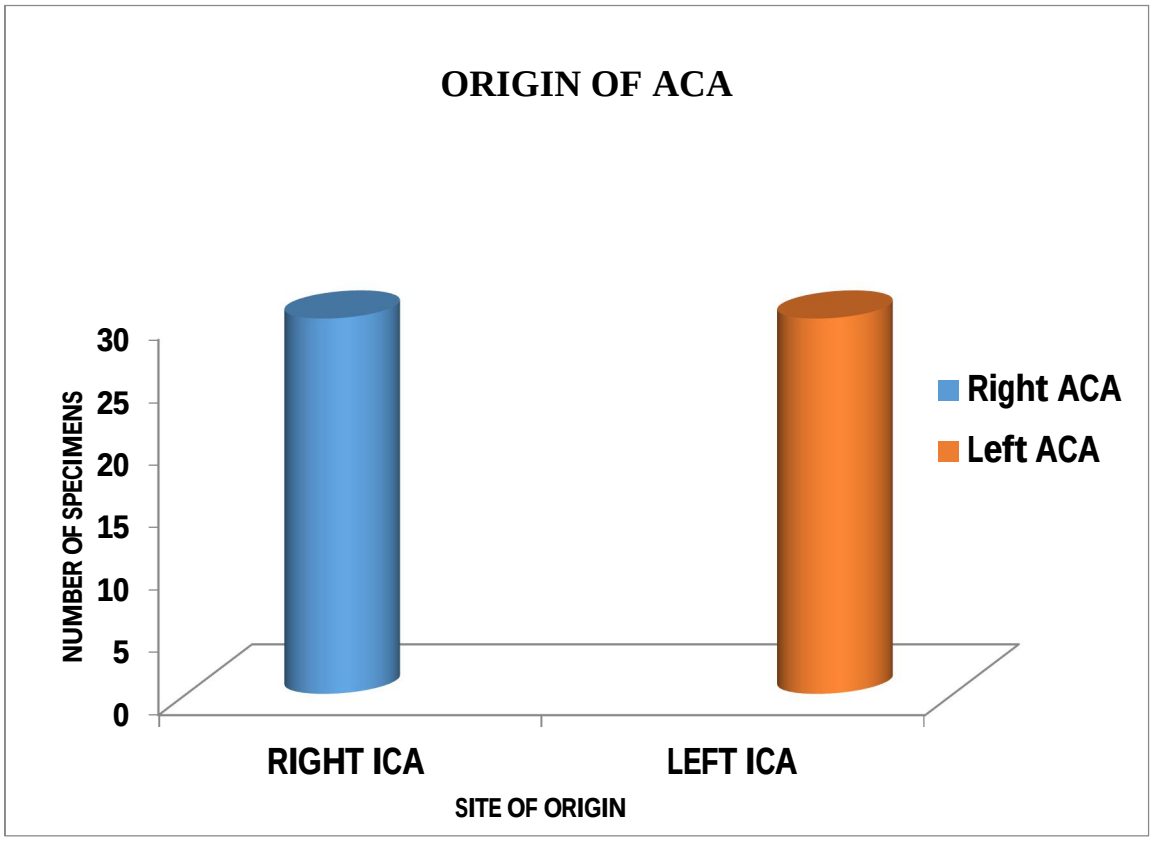


Fig. 2 a : Relation of ACA to optic nerve
Right ACA passes inferior to the optic nerve
1. ICA 2. ACA 3. Optic Nerve

Fig. 2 b : Relation of ACA to optic chiasma
Right ACA passes above the optic chiasma
1. Right ACA 2. Optic chiasma

II. RELATION OF THE ACA ARTERY TO OPTIC NERVE AND OPTIC CHIASMA

On the right side, out of 30 cerebral hemispheres, ACA passed above the optic nerve in 23 specimens (76.7%). In 6 specimens, ACAs passed above the optic chiasma (20%). In one specimen the optic nerve passed below the optic chiasma (3.3%).

On the left side, out of 30 cerebral hemispheres, ACAs passed above the optic nerve in 23 specimens (76.7%) and ACAs passed above the optic chiasma in 7 specimens (23%)

TABLE1: Relation of the ACA to Optic nerve and Optic chiasma

Cerebral hemispheres	Above OP.N		Above OP.C		Below OP.C	
	Number	%	Number	%	Number	%
Right	23	76.7	6	20	1	3.3
Left	23	76.7	7	23	-	-

CHART 2: Relation of the ACA to Optic nerve and Optic chiasma

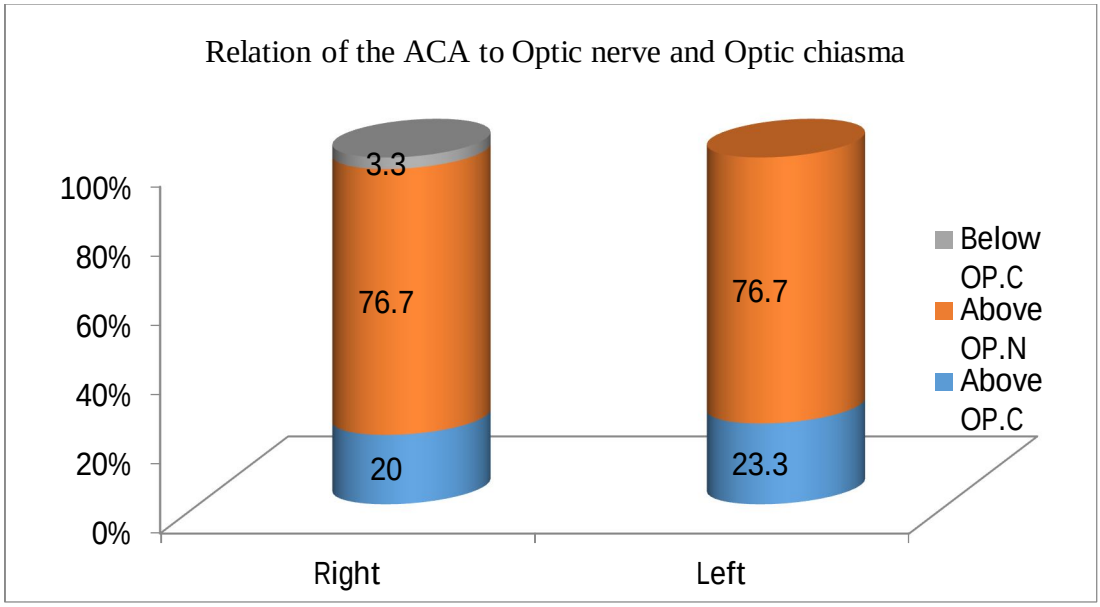


Fig. 3 : A1 segment of ACA

(1) A1 segment of ACA (RT)

III. A1 SEGMENT OF ACA

a) NUMBER OF A1 SEGMENTS OF ACA:

In all the sixty hemispheres, the Anterior Cerebral Arteries of both right and left sides were single. Duplication or triplication of the ACA was not observed in the present study.

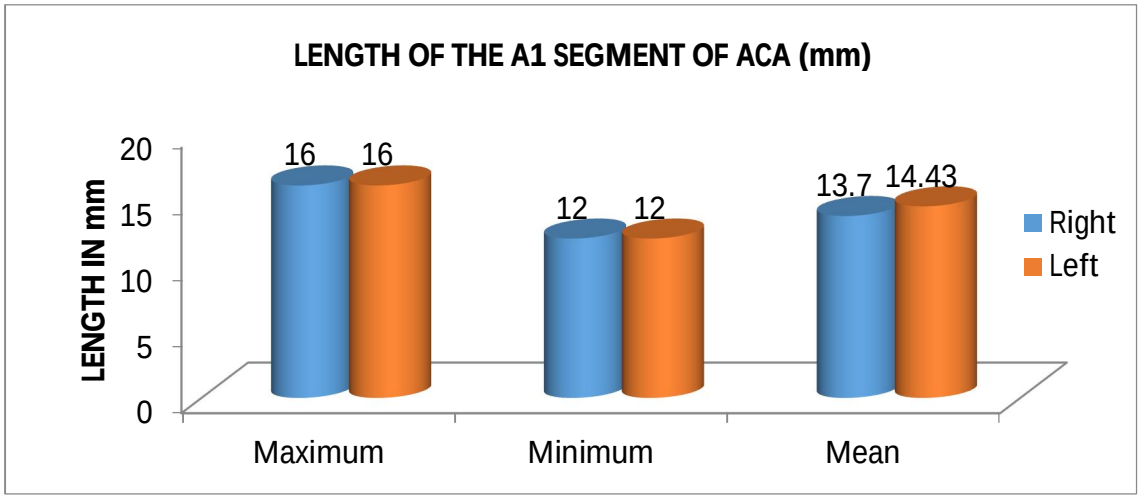
b) LENGTH OF THE A1 SEGMENT OF ACA:

The length of A1 segment in all the sixty hemispheres was measured. The maximum length of A1 segment was 16 mm on both right and left sides. The minimum length of A1 segment observed was 12mm on both sides.

TABLE 2: Length of the A1 segment of ACA (mm)

A1 segment	Number of cerebral hemispheres	Maximum length in mm	Minimum length in mm	Mean length in mm	SD
Right	30	16.00	12.00	13.70	1.02
Left	30	16.00	12.00	14.43	0.97

CHART 3: Length of the A1 segment of ACA (mm)



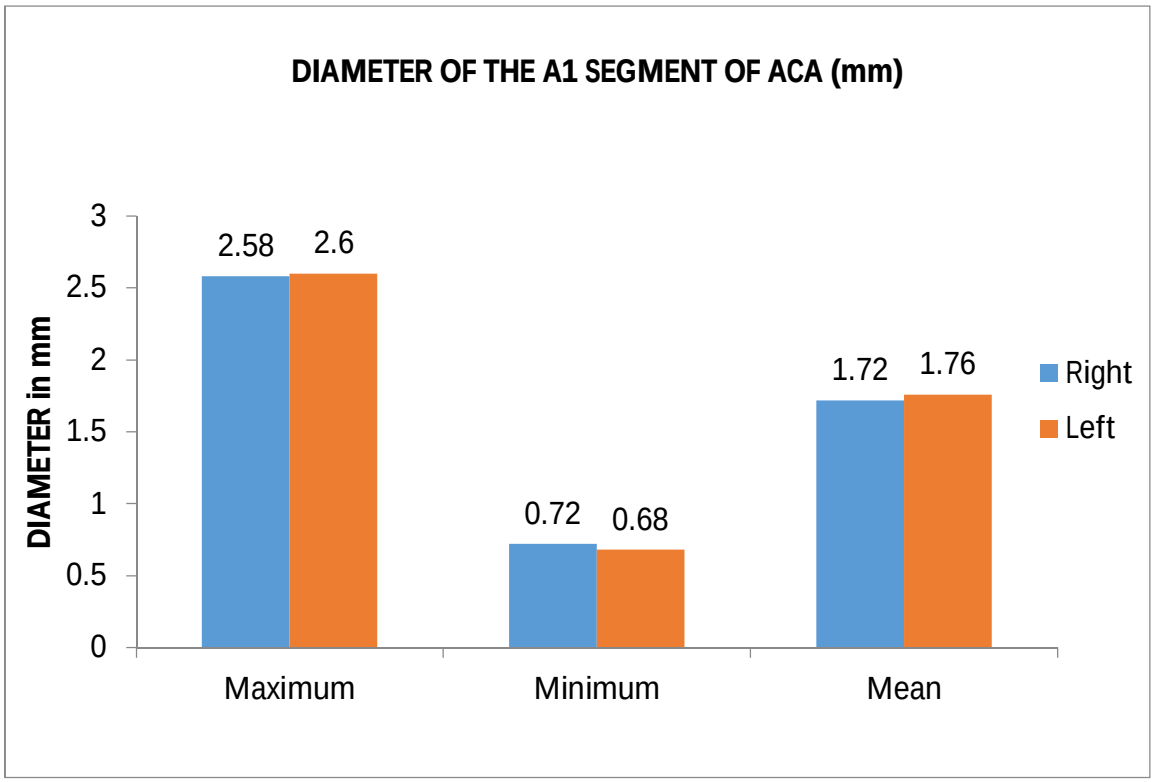
C) DIAMETER OF A1 THE SEGMENT OF ACA:

The diameter of A1 segment in all the sixty hemispheres was measured. The maximum diameter of the A1 segment observed on the right side was 2.58 mm and on left side was 2.60 mm. The minimum diameters for the left and right sides were 0.68 and 0.72mm respectively

TABLE 3: Diameter of the A1 segment of ACA (mm)

A1 segment	Number of cerebral hemispheres	Maximum Diameter in mm	Minimum Diameter in mm	Mean Diameter in mm	SD
Right	30	2.58	0.72	1.72	0.34
Left	30	2.60	0.68	1.76	0.41

CHART 4: Diameter of the A1 segment of ACA (mm)



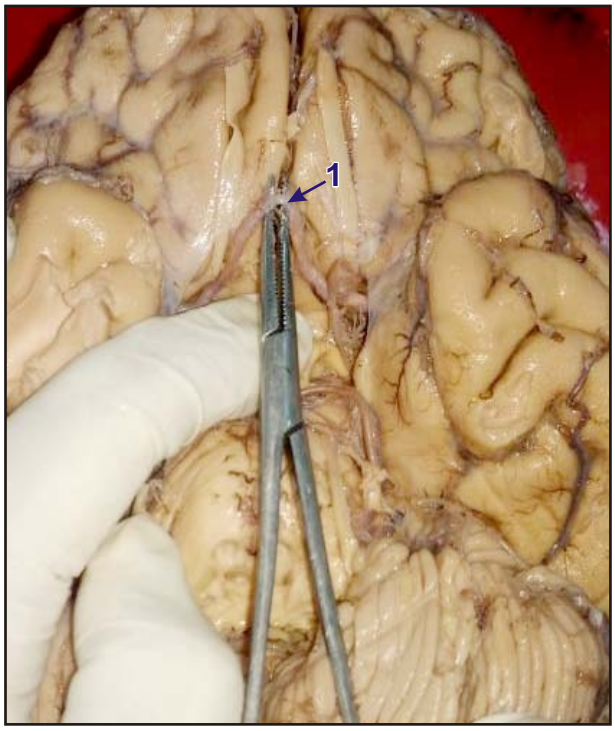


Fig. 4 a : Anterior Communicating Artery

(1) ACOA

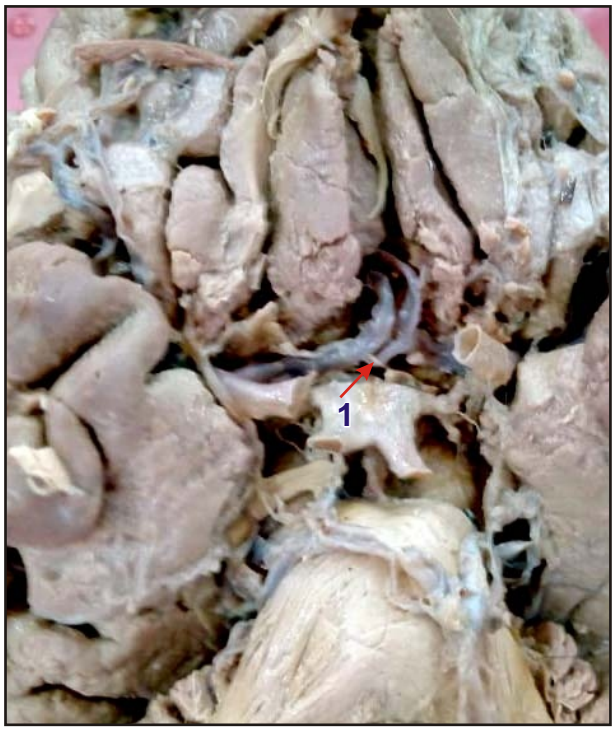


Fig. 4 b. Oblique Course of ACoA

(1) ACoA

IV. ANTERIOR COMMUNICATING ARTERY:

a) NUMBER OF ACoA:

Single ACoA was observed in all the 30 specimens. Duplication or triplication of the ACoA was not observed.

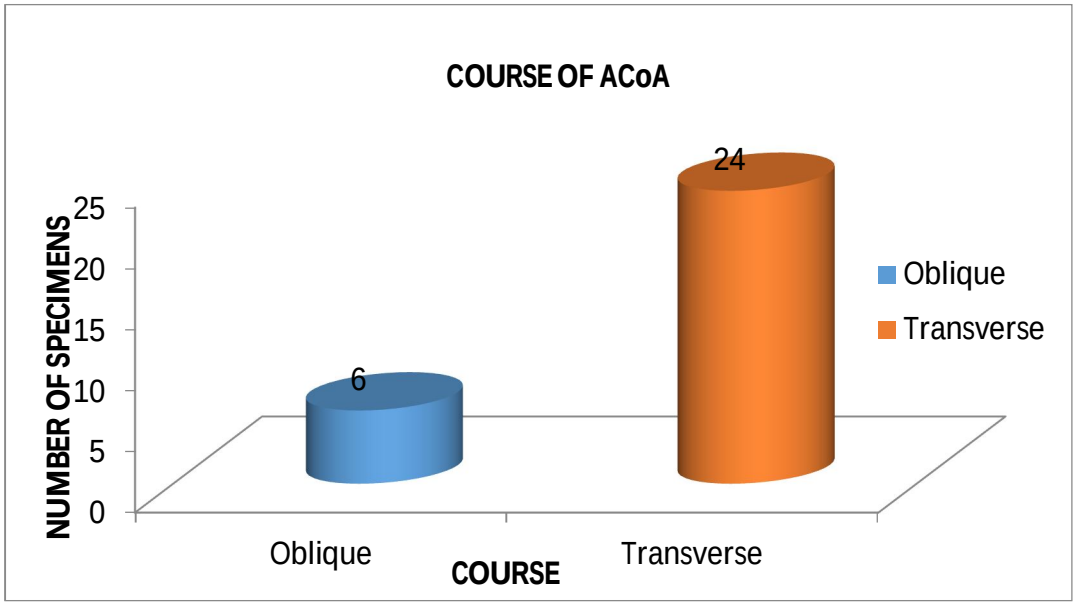
b) COURSE OF ACoA:

In the present study, out of the thirty specimens, transverse ACoA was observed in twenty four specimens, and oblique ACoA in six specimens.

TABLE-4: Course of ACoA

COURSE	Number	Percentage
Transverse	24	80%
Oblique	6	20%

CHART 5: Course of ACoA



c) **LENGTH OF ACoA:**

The maximum length of ACoA observed was 4 mm and the minimum length was 2 mm. The mean length of ACoA observed in the study was 2.81mm.

d) DIAMETER OF ACoA:

The maximum diameter of ACoA observed was 3.07mm and the minimum observed was 2.01mm. The mean diameter of ACoA observed in the study was 2.52mm.

TABLE 6: Length of ACoA (mm):

Dimension of ACoA	Number of specimens	Maximum length (mm)	Minimum length (mm)	Mean length (mm)	SD
Length	30	4	2	2.81	0.66

CHART 7: Length of ACoA (mm)

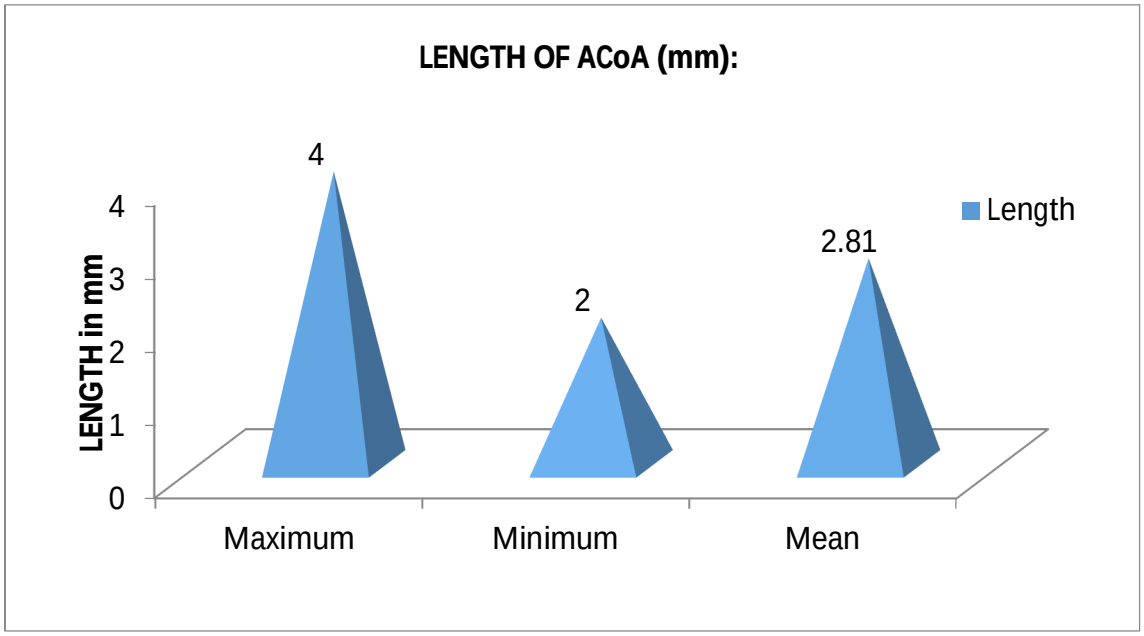


TABLE 7: Diameter of ACoA (mm)

Dimension of ACoA	Number of specimens	Maximum diameter (mm)	Minimum diameter (mm)	Mean diameter (mm)	SD
Diameter	30	3.07	2.01	2.52	0.35

CHART 8: Diameter of ACoA (mm)

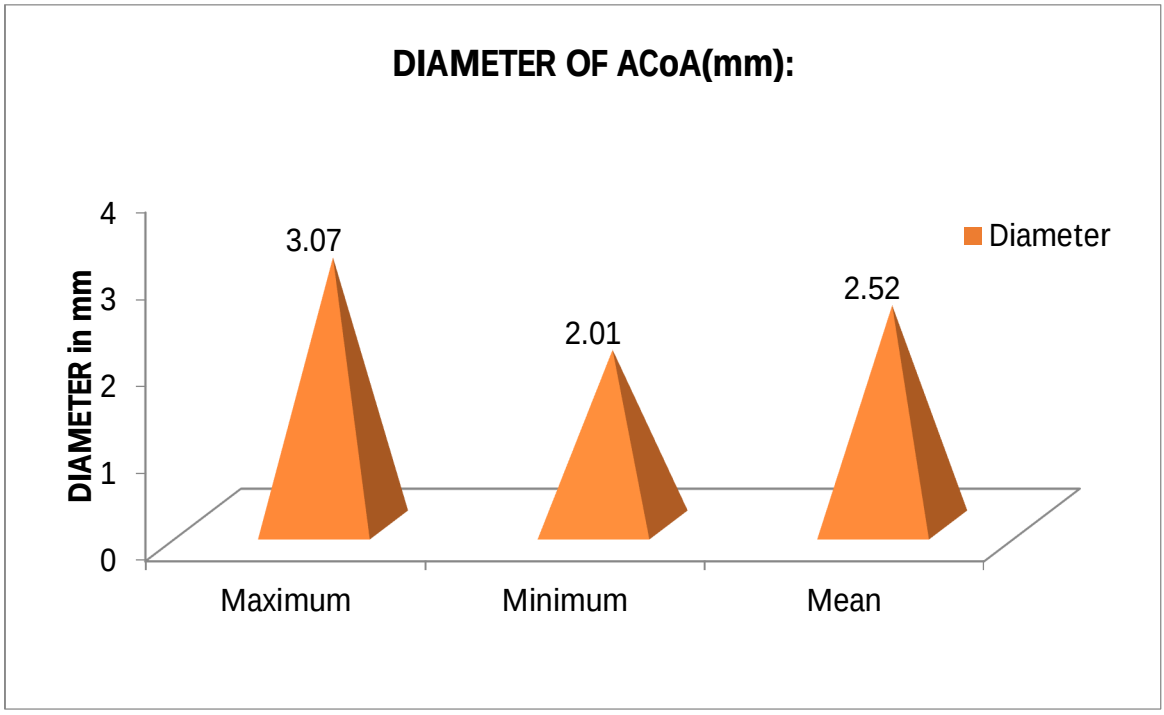


Fig. 5 : RAH arising from the A2 Segment of ACA

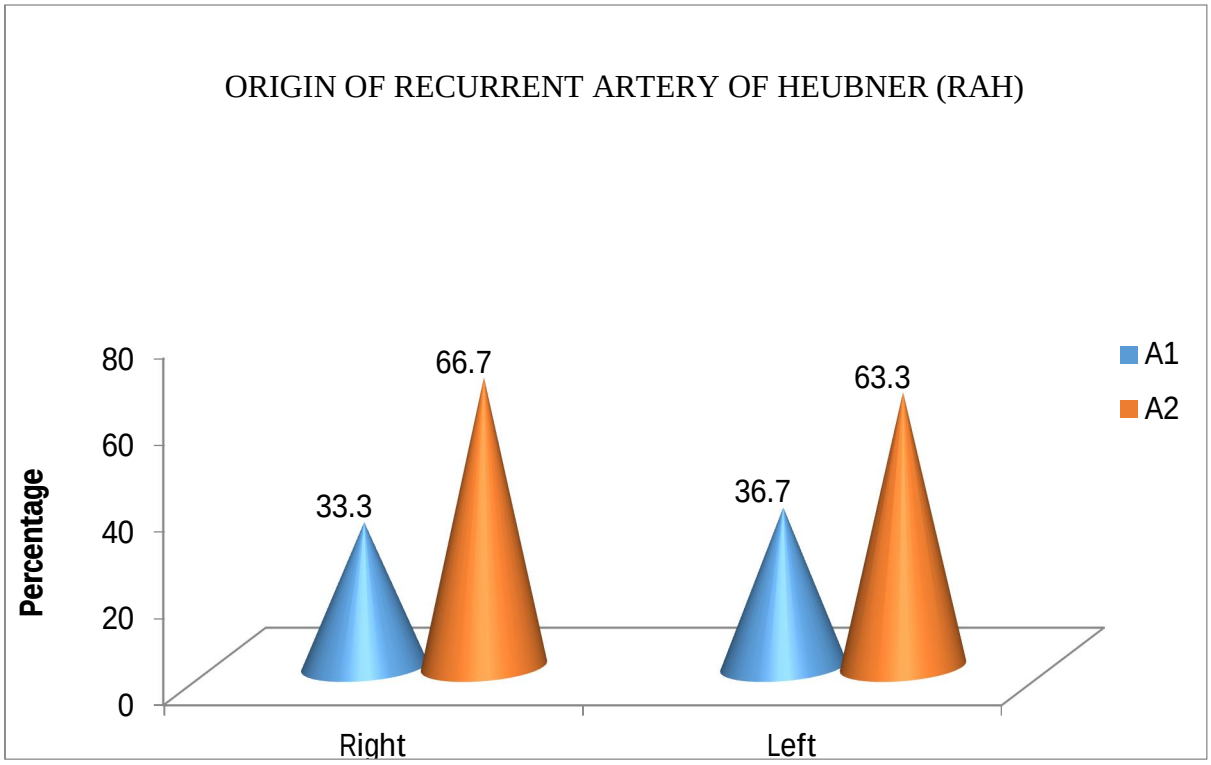
V) ORIGIN OF RECURRENT ARTERY OF HEUBNER (RAH):

In the present study, on the right side, the RAH originated from the A1 segment in 10 cases and from the A2 segment in 20 cases. On the left side, it originated from the A1 segment in 11 cases and from the A2 segment in 19 cases.

TABLE- 8: Origin of Recurrent Artery of Heubner (RAH)

Cerebral Hemisphere	From the A1segment of ACA		From the A2 segment of ACA	
	Number	%	Number	%
Right	10	33.3	20	66.70
Left	11	36.7	19	63.3

CHART 9: Origin of Recurrent Artery of Heubner (RAH):



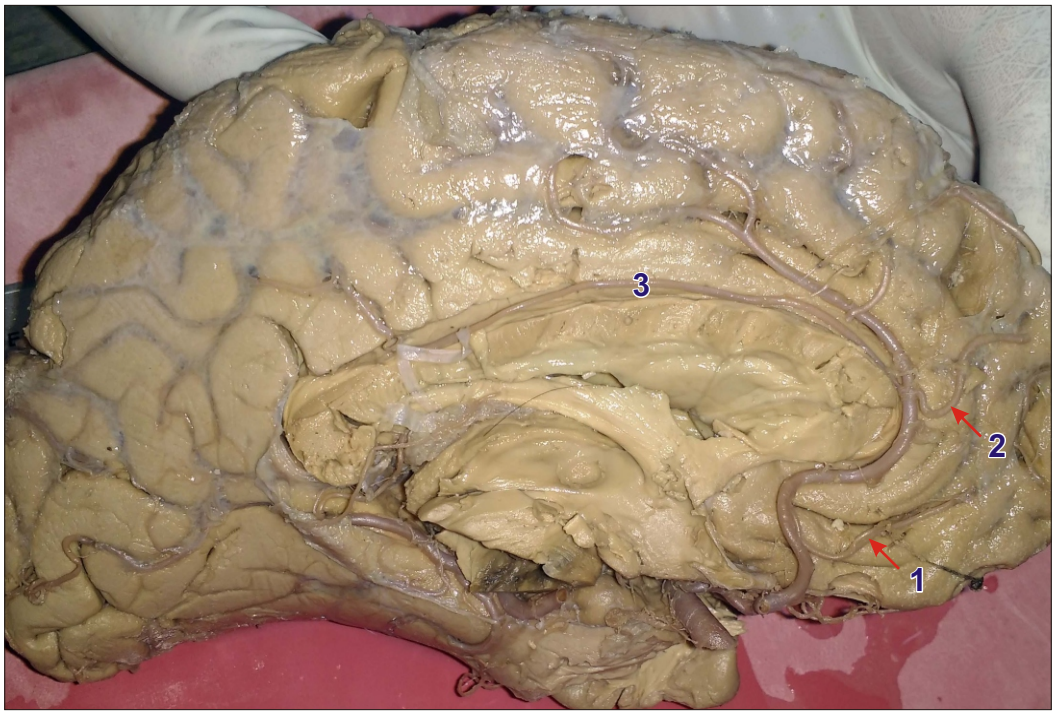


Fig. 6 a : Branches of ACA

(1) OFA (2) FPA (3) CMA

VI) ORBITO-FRONTAL ARTERY (OFA)

In the present study, in all the sixty hemispheres, OFA arose from the A2 segment of the Anterior Cerebral Artery of the same side.

The average distance of the origin of OFA from the ACA & ACoA junction on the right side was 14.20 mm and on the left side the distance measured was 16.37mm.

The maximum distance of the origin of OFA from the ACA & ACoA junction was 24mm and the minimum distance was 10mm. The mean distance observed in the present study was 15.28 mm

TABLE-9: Distance of origin of OFA from ACA and ACoA junction (mm)

Cerebral hemisphere	Number of specimens	Maximum distance in mm	Minimum Distance in mm	Mean Distance in mm	SD
Right	30	22.00	10.00	14.20	3.64
Left	30	24.00	11.00	16.37	3.32

CHART- 10: Distance of origin of OFA from ACA and ACoA junction (mm)

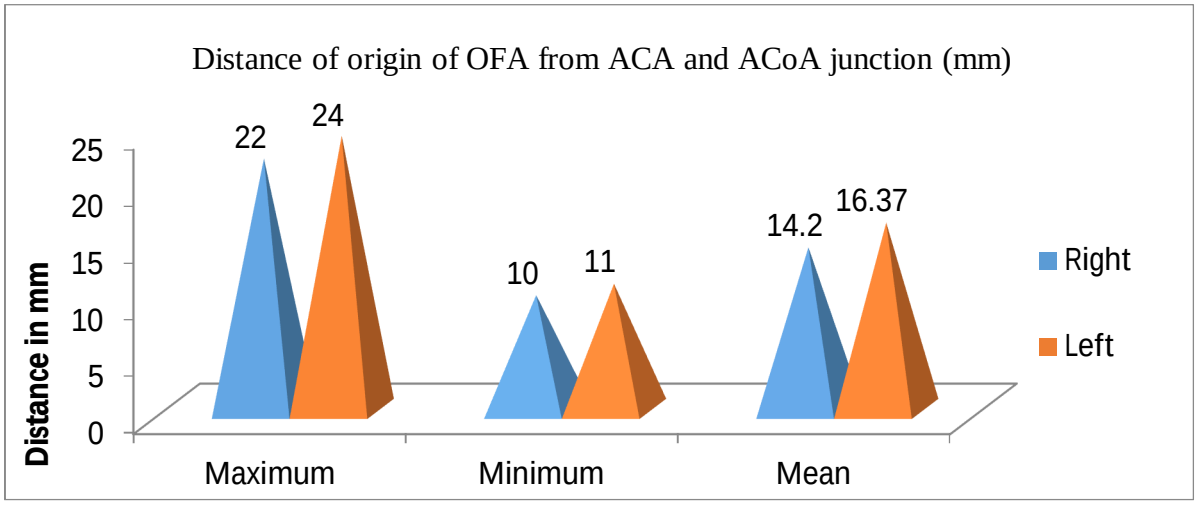
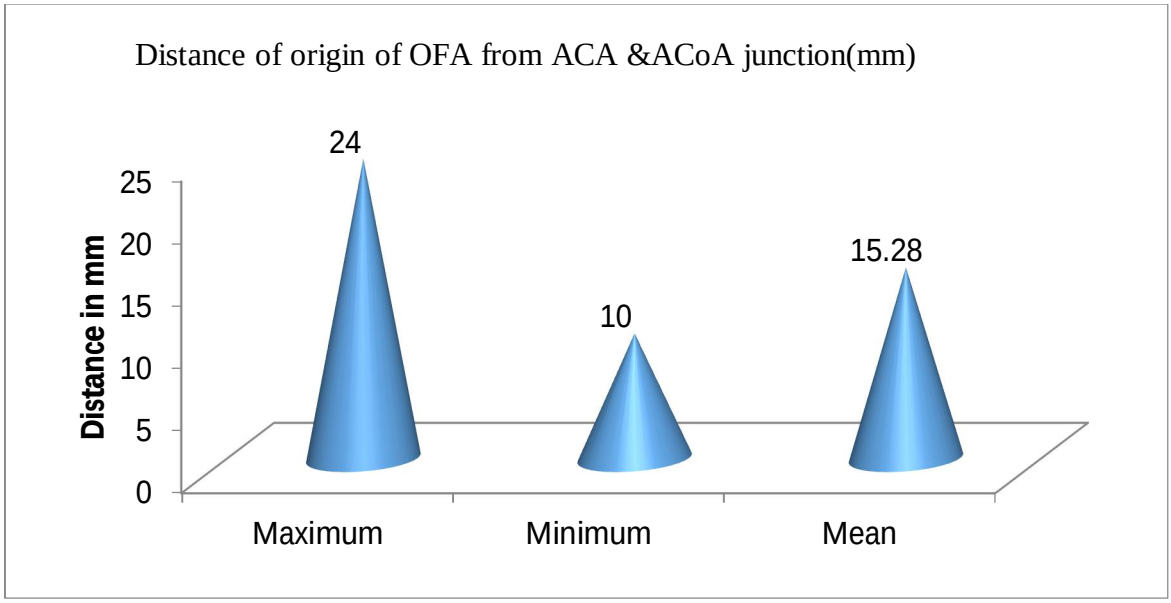


TABLE 10: Distance of origin of OFA from ACA and ACoA junction (mm)

Maximum distance in mm	Minimum Distance in mm	Mean Distance in mm	SD
24	10	15.28	3.62

CHART- 11: Distance of origin of OFA from ACA and ACoA junction (mm)



VII) FRONTO POLAR ARTERY:

a) Origin of FPA:

In the present study in all the sixty hemispheres, FPA originated from the A2 segment of the ACA of the same side.

b) Distance of origin of FPA from ACA and ACoA junction:

The average distance of the origin of FPA from the ACA & ACoA junction on the right side was 30.37 mm and the average distance of the origin of FPA from the ACA & ACoA junction on the left side was 34.30 mm.

The maximum distance of the origin of FPA from the ACA & ACoA junction was 47 mm and the minimum distance between the two was 21 mm. The average distance between the origin of FPA and the ACA & ACoA junction observed in the present study was 32.33mm.

TABLE-11 Distance of origin of FPA from ACA and ACoA junction

Cerebral hemisphere	Number of specimens	Maximum Distance in mm	Minimum Distance in mm	Mean Distance in mm	SD
Right	30	46.00	21.00	30.37	7.39
Left	30	47.00	23.00	34.30	6.77

CHART 12: Distance of origin of FPA from ACA and ACoA junction (mm)

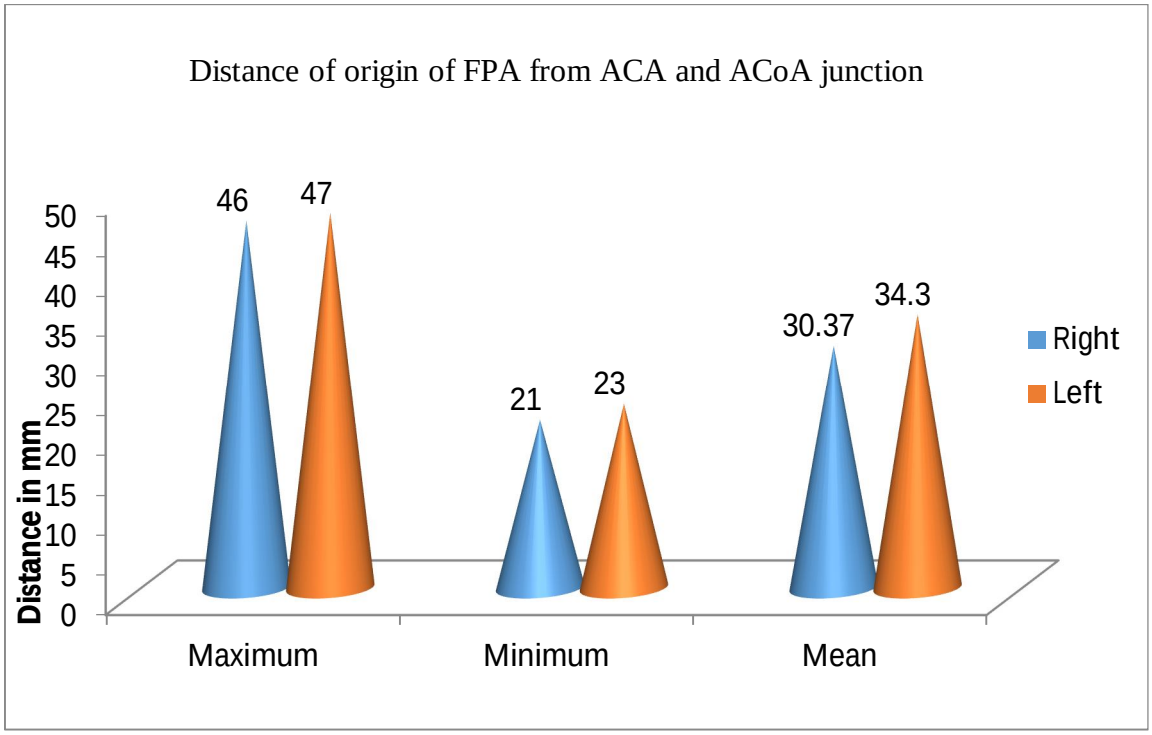
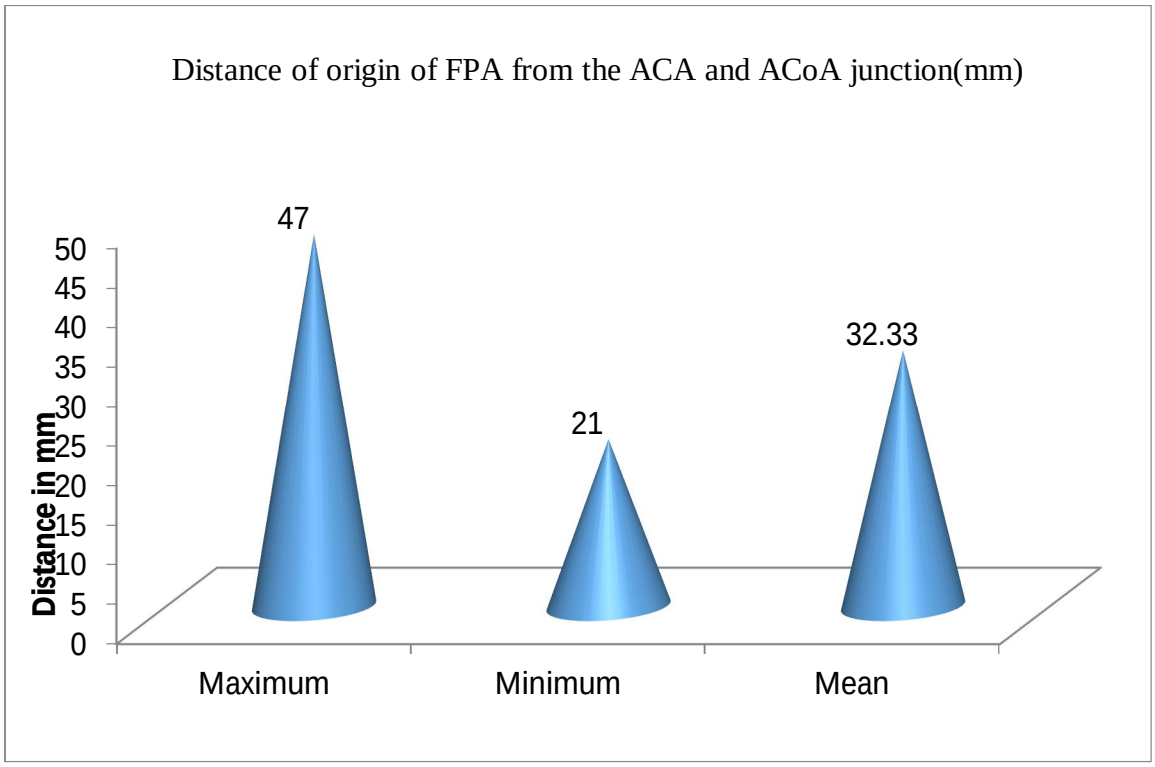


TABLE 12: Distance of origin of FPA from ACA and ACoA junction (mm)

Maximum distance in mm	Minimum distance in mm	Mean distance in mm	SD
47	21	32	7.30

CHART 13: Distance of origin of FPA from ACA and ACoA junction (mm)



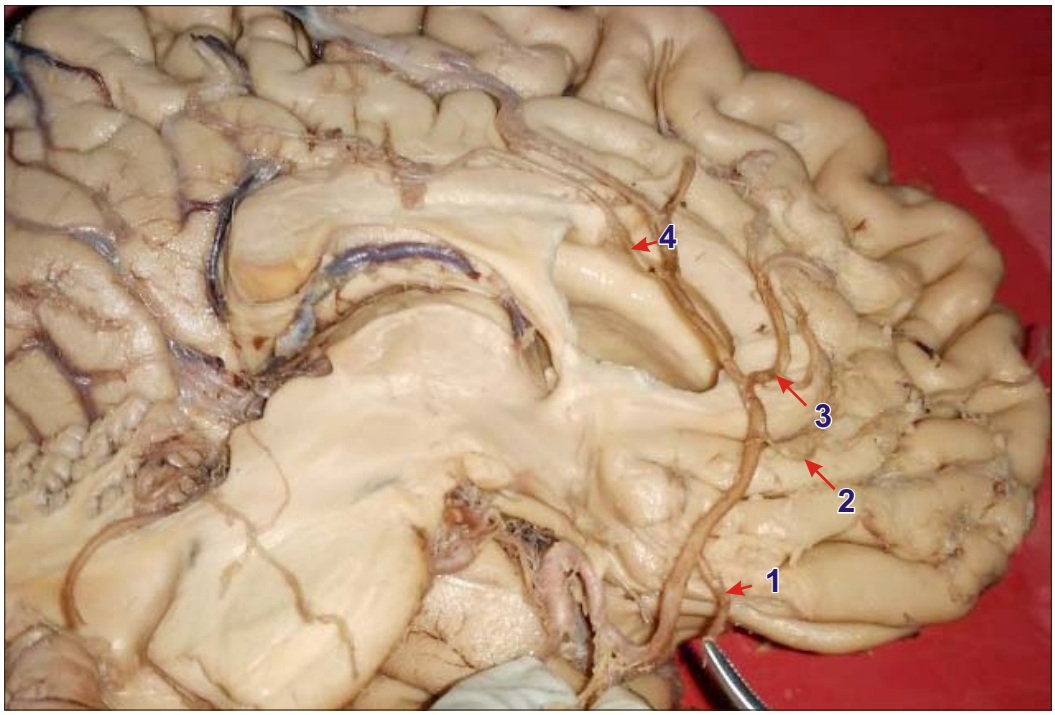


Fig. 6 b : Branches of ACA

(1) RAH from the A2 segment (2) OFA (3) FPA (4) CMA

VIII) CALLOSO MARGINAL ARTERY:

In all the sixty hemispheres, the CMA arose from the A2 segment of the ACA. The average distance between the origin of CMA and the ACA & ACoA junction on the right side was 49.87 mm and on the left side it was 53.87mm.

TABLE 13: Distance of origin of CMA from ACA and ACoA junction (mm)

Side	Number	Maximum	Minimum	Mean	SD
Right	30	64.00	37.00	49.87	7.37
Left	30	66.00	44.00	53.87	5.79

CHART 14: Distance of origin of CMA from ACA and ACoA junction (mm)

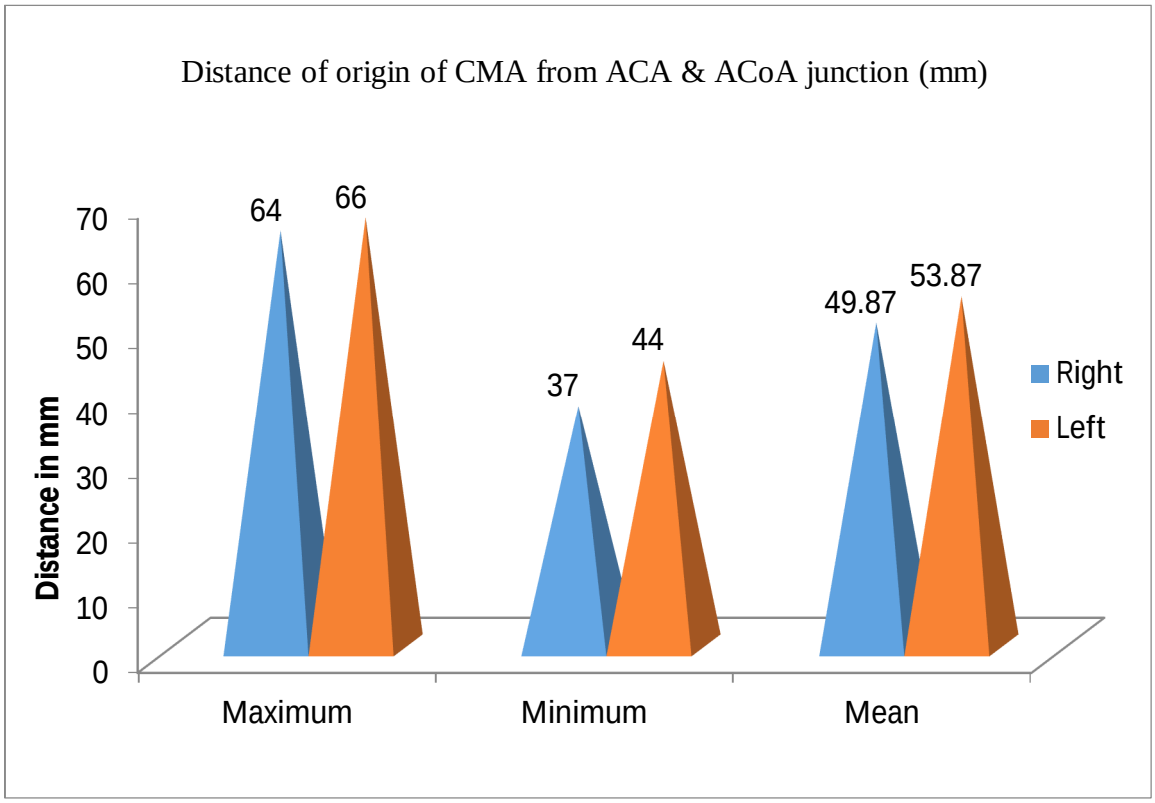
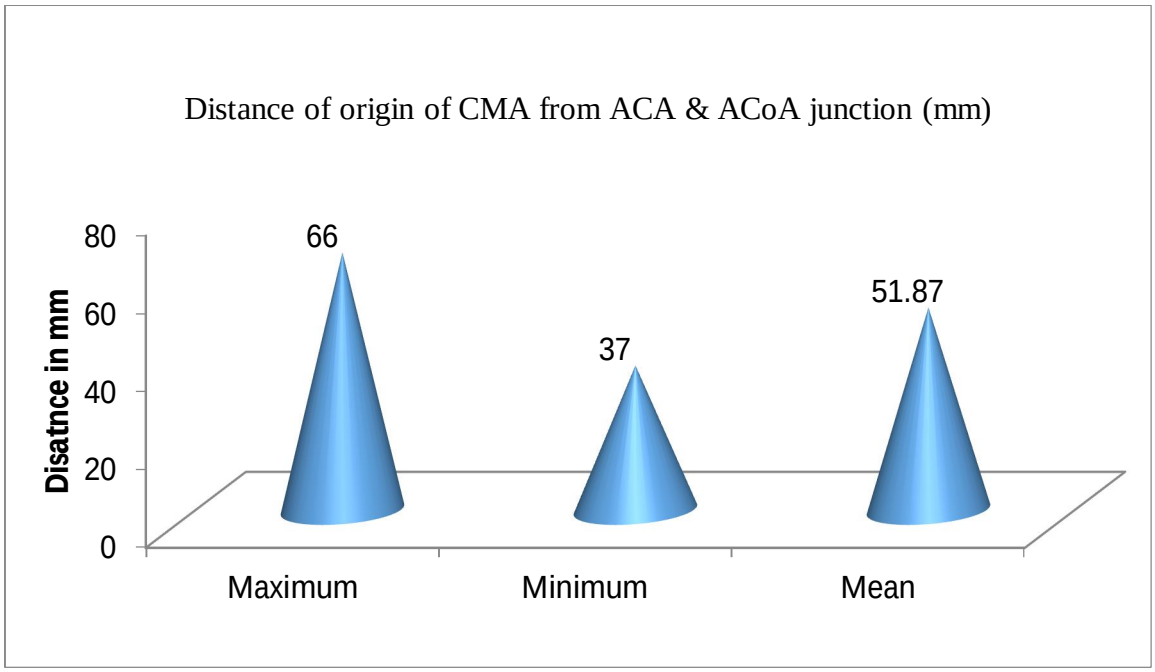


TABLE 14: Distance of origin of CMA from ACA and ACoA junction (mm)

Maximum distance in mm	Minimum distance in mm	Mean distance in mm	SD
66	37	51.87	6.87

CHART 15: Distance of origin of CMA from ACA and ACoA junction (mm)



The average distance between the origin of CMA and junction between ACA & ACoA observed in the present study was 51.87 mm

Discussion

DISCUSSION

I) ORIGIN OF ACA

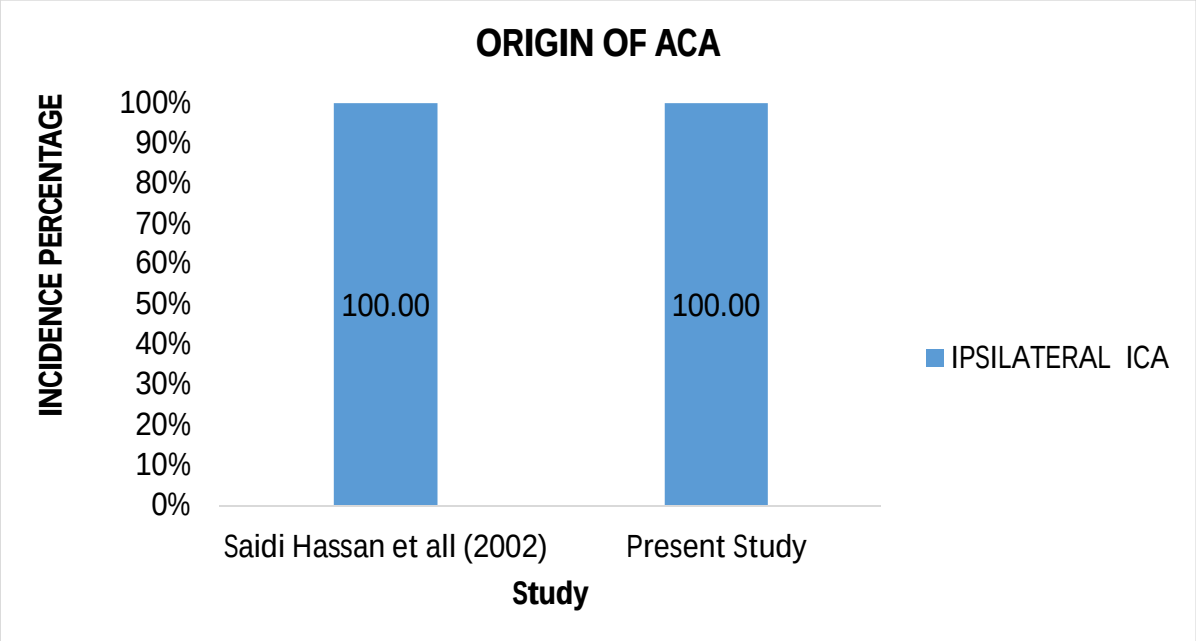
Saidi hassan et al [54] (2002) in 72 cerebral hemispheres, observed ACAs of all hemispheres originated from the ICA of the same side.

Rishi Pokrel et al [51] (2013) during his routine dissection observed a case where both the right and left ACAs arose from right ICA which was slightly larger than left ICA.

Mahajan et al [33] (2018) observed an incidental anomalous variation of left ACA arising from the right ICA.

In the present study, in all the sixty hemispheres, ACA originated from the ICAs of the same side. No variation was observed with respect to the origin of ACA. The present study coincides with the study conducted by Saidi Hassan et al.

CHART 16: Origin of ACA



During the clipping of ACoA aneurysms, anomalies in the origin of A1 segment may bring operative significance in the management.

II) RELATION OF ACA TO OPTIC NERVE AND OPTIC CHIASMA:

SB Pai et al [42] (2005) observed that the ACA courses anteromedially to cross the optic nerve and optic chiasma to communicate with opposite ACA through ACoA.

J.Peltier et al [44] (2007) reported that in a 61 year old female individual, on both sides the precommunicating parts of the ACA were found to course inferior to the ipsilateral optic nerves.

Cessyjob et al [9] (2016) observed that the right Anterior Cerebral Artery was related to optic chiasma while the left crosses well in advance of the chiasma.

In the present study, out of 60 ACAs, 46 ACAs passed above the optic nerve, 13 ACAs passed above the optic chiasma and in one specimen on the right side the ACA passed below the optic chiasma.

The relation of ACA to optic nerve and chiasma scores surgical significance in planning for temporary vascular clipping in ACoA aneurysmal procedures.

TABLE- 15: Relation of ACA to optic nerve and optic chiasma

Name of the study	RELATION OF ACA			
	Above the Opt. Nerve	**Below the Opt. Nerve**	**Above the Opt. Chiasma**	**Below the Opt. Chiasma**
SB Pai et al (2005) Bangalore	+	-	+	-
Cessy Job (2016) Kerala	+	-	+	-
Present Study	+ (46)	-	+ (13)	+ (1)

III) A1 SEGMENT OF THE ACA

a) NUMBER OF A1 SEGMENTS OF THE ACA:

Sandhya et al [55] (2013) out of 112 cerebral hemispheres, observed that 97.3% of A1 segments were single and 1.1% of A1 segments were double. In 1.8% of the specimens A1 segments were absent.

Shwetha et al [25] (2013) out of 30 brain hemispheres, in 29 specimens (96.6%) A1 segments were single and in one specimen (3.3%) duplication of the A1 segment was observed.

Cessy Job et al [9] (2016) in his study in 104 specimens observed that A1 segment was absent in one specimen (0.96%) and partial duplication of the A1 segment in two cases (1.92%).

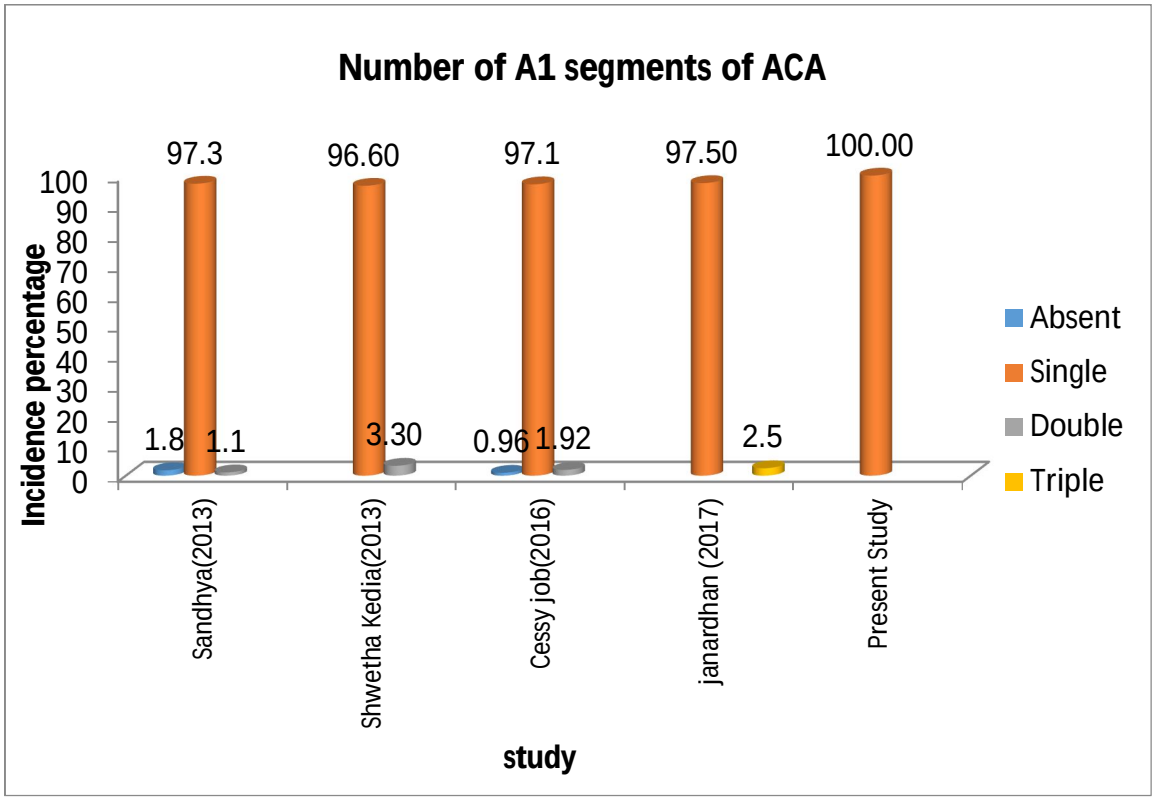
Janardhan Rao et al [32] (2017) in his study in 80 cerebral hemispheres, observed that 97.5% (78 specimens) of A1 segments were single. He also observed triplication in 2.5% cases (2 specimens).

In the present study in all the 60 cerebral hemispheres, A1 segments were single. There was no double or triple ACAs observed.

Table16: Number of A1 segments of ACA (%)

Name of the study	Absent	Single	Double	Triple
Sandhya et al (2013) Maharastra	1.8	97.3	1.1	
Shwetha Kedia et al (2013) Chandigarh		96.60	3.30	
Cessy job et al (2016) Kerala	0.96	97.1	1.92	
Janardhan et al (2017) Hyderabad		97.50		2.5
Present Study		100.00		

CHART 17: Number of A1 segments of ACA



a) LENGTH OF THE A1 SEGMENT OF ACA (mm)

Sylvia Kamath et al [59] (1981) observed the maximum length of A1 segment on the right side was 25.6mm and the minimum length of A1 on the same side was 0.34 mm. The mean length of A1 segment observed on the right side was 14.70mm.

On the left side, the maximum length of the A1 segment observed was 21mm and the minimum length observed was 3.10 mm. The mean length of the A1 segment observed on the left side was 13.80 mm

Smitha B Shinde et al [56] (2016) on the right side, the maximum length of the A1 segment observed was 15mm. The minimum length of the A1 segment observed was 11mm. The mean length of the A1 segment observed on the right side was 13mm.

On the left side, the maximum length of the A1 segment observed was 13mm. The minimum length of the A1 segment observed was 11mm. The mean length of the A1 segment observed on the left side was 12.04mm

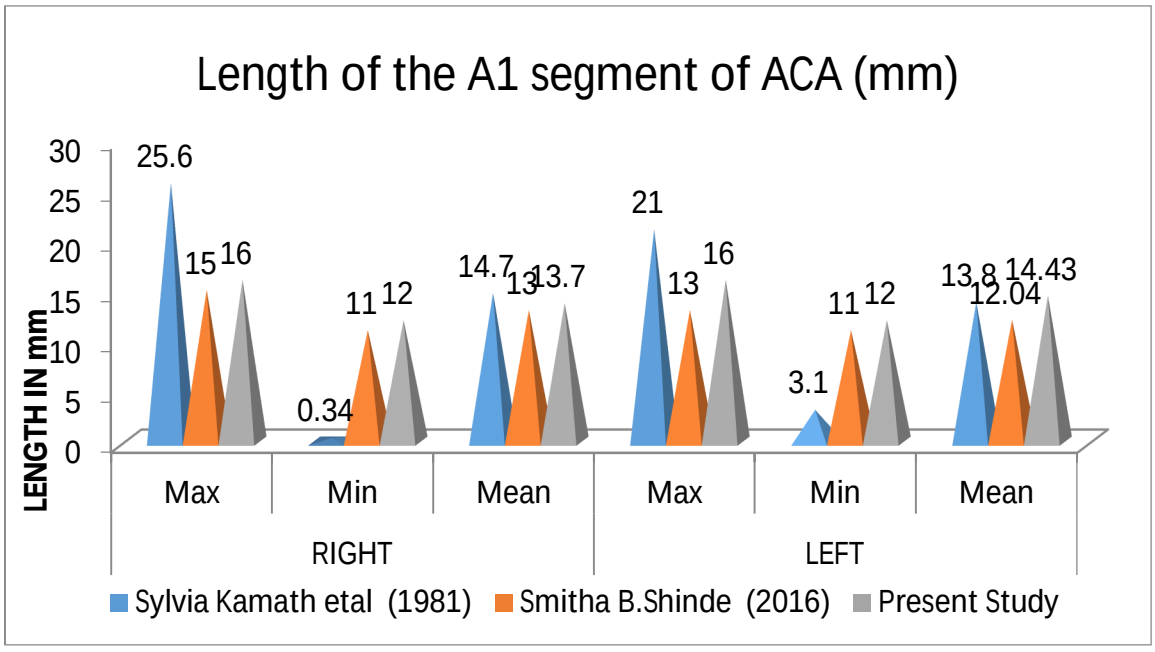
In the present study, on the right side, the maximum length of the A1 segment observed was 16mm. The minimum length of the A1 segment observed was 12mm. The mean length of the A1 segment observed on the right side was 13.70 mm.

On the left side, the maximum length of the A1 segment observed was 16mm. The minimum length of the A1 segment observed was 12mm. The mean length of the A1 segment observed on the left side was 14.43 mm. The present study measurements were close to the results obtained by Sylvia Kamath in his study. However measurements noted in all the above studies were within the range observed in the present study.

TABLE-17 Length of the A1 segment of ACA (mm)

Name of the study	RIGHT			LEFT		
	Max (mm)	Min (mm)	Mean (mm)	Max (mm)	Min (mm)	Mean (mm)
SylviaKamath et al (1981) Bangalore	25.60	0.34	14.70	21.00	3.10	13.80
SmithaB.Shinde (2016) Aurungabad	15.00	11.00	13.00	13.00	11.00	12.04
Present Study	16.00	12.00	13.70	16.00	12.00	14.43

CHART 18: Length of the A1 segment of ACA (mm)



b) DIAMETER OF A1 SEGMENT (mm)

Sylvia Kamath et al [59] (1981) on the right side, the maximum diameter of the A1 segment observed was 3.90 mm. The minimum diameter of the A1 segment observed was 0.60mm. The mean diameter of the A1 segment observed on the right side was 2.20mm. On the left side, the maximum diameter of the A1 segment observed was 3.60mm. The minimum diameter of the A1 segment observed was 1.10mm. The mean diameter of the A1 segment observed on the left side was 2.40mm

Smitha B. Shinde et al [56] (2016) on the right side, the maximum diameter of the A1 segment observed was 2.50mm. The minimum diameter of the A1 segment observed was 1mm. The mean diameter of the A1 segment observed on the right side was 2.05mm. On the left side, the maximum diameter of the A1 segment observed was 2.8mm. The minimum diameter of the A1 segment observed was 1mm. The mean diameter of the A1 segment on the left side is 2.08 mm.

In the present study, on the right side, the maximum diameter of the A1 segment observed was 2.58 mm. The minimum diameter of the A1 segment observed was 0.72mm. The mean diameter of the A1 segment observed was 1.72mm. On the left side, the maximum diameter of the A1 segment was 2.60mm. The minimum diameter of the A1 segment observed was 0.68 mm. The mean diameter observed on the left side was 1.76mm.The measurements of the present

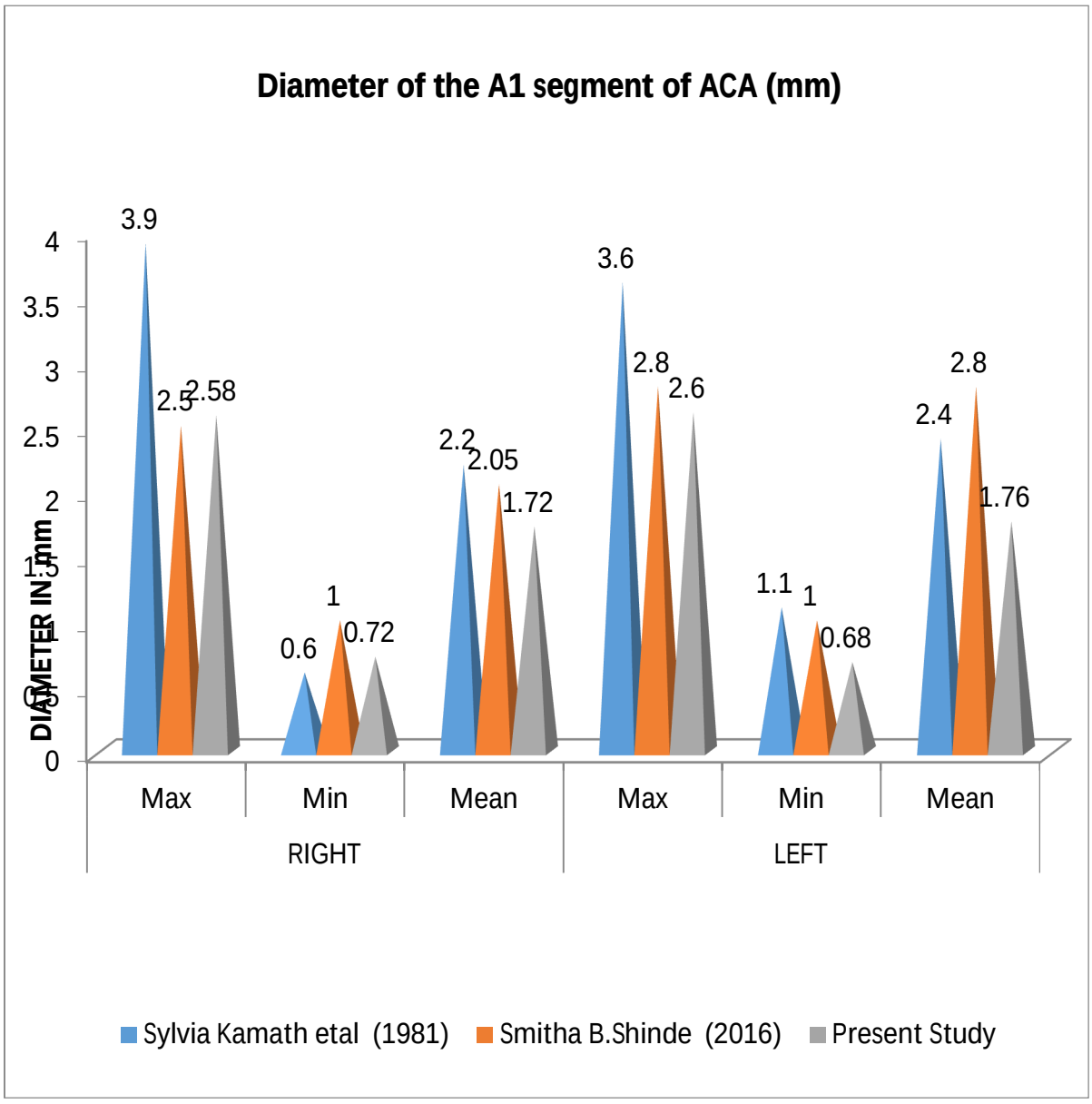
study coincides with the results observed by both Sylvia and Smitha B Shinde in their studies.

The Anatomical variations in the number and diameter of the A1 segment constitute the main indicators for preoperative planning of ACoA aneurysmal clipping procedures. The incidence of intraoperative ACoA aneurysmal rupture during clipping is more common in short A1 segment. Moreover, the surgical access to the inferiorly pointing ruptured ACoA aneuryms is more difficult in short A1 segment. In aneurysm of ACA with unequal diameter of both sides, the base of the aneurysm arises on the side of larger A1 and the dome points towards the side of the hypoplastic A1.

TABLE 18: Diameter of the A1 segment of ACA (mm)

Name of the study	RIGHT			LEFT		
	Max	**Min**	**Mean**	**Max**	**Min**	**Mean**
Sylvia Kamath et al (1981)Bangalore	3.90	0.60	2.20	3.60	1.10	2.40
Smitha B.Shinde et al (2016)Aurungabad	2.50	1.00	2.05	2.80	1.00	2.08
Present Study	2.58	0.72	1.72	2.60	0.68	1.76

CHART 19: Diameter of the A1 segment of ACA (mm)



IV) ANTERIOR COMMUNICATING ARTERY.

a) NUMBER OF ACoA:

Gholam Hussain Khosravi et al [18] (2001) out of 101 specimens, he observed in 18 specimens (18%) ACoA was duplicated.

Saidi Hassan et al [54] (2002) out of 36 brains, he observed complete duplication of the Anterior Communicating Artery in 14% of his study specimens.

Esra et al [14] (2004) out of 30 cases ACoAs were single in 29 specimens (96.6%), and double ACoA was observed in one case (3.3%).

S B Pai et al [42] (2005) he observed that in two out of ten cases, there was duplication of the ACoA. In one specimen the duplication was thin rudimentary. The other better formed duplication of the ACoA gave origin to a perforator.

AtthapornBoongird et al [6] (2009) they observed that out of the fifty specimens studied, in 41 specimens had single ACoA. Multiple ACoA were found in nine cases (18%), which included eight cases of double ACoA and one triple ACoA.

Sandhya et al [55] (2013) out of the 112 specimens studied, observed single ACoA in 90.1% of the specimens and double ACoAs in 9.8% of the specimens.

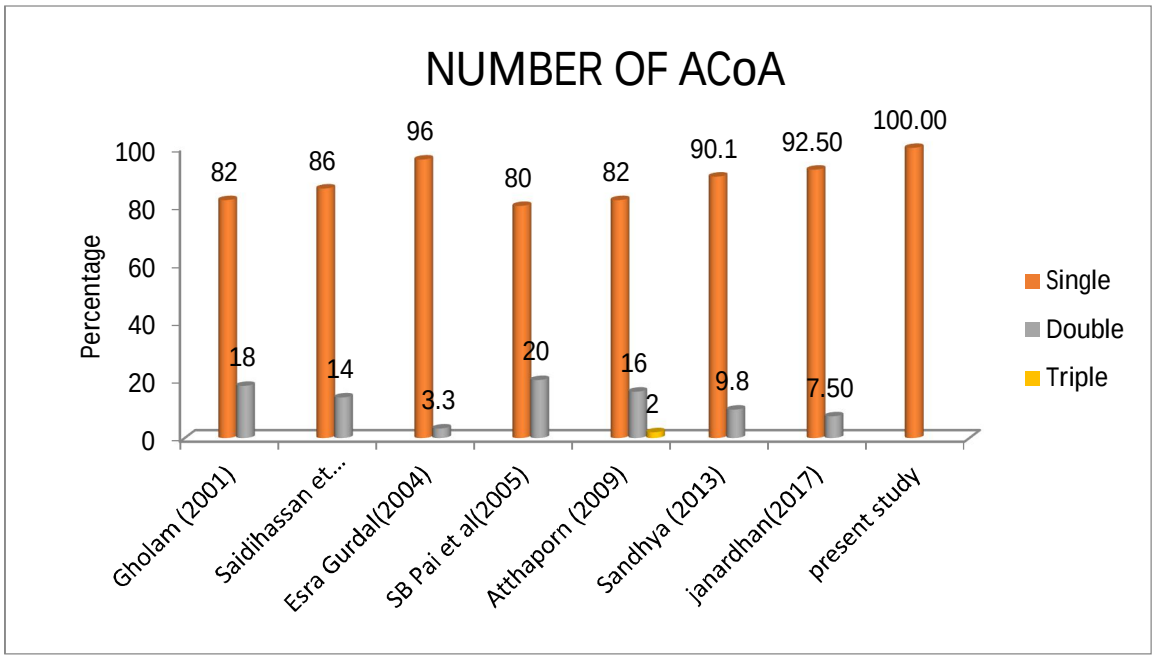
Janardhan Rao et al [32] (2017) observed single ACoA in 92.5% of the specimens, and double AcoA in 7.5% of the specimens.

In the present study, in all the 30 specimens, ACoA was single. Duplication or triplication of the ACoA was not observed.

TABLE19: Number of ACoA

Name of the study	Single	Double	Triple
Gholam et al (2001) Tehran	82	18	
Saidihassan et al (2002) kenya	86	14	
EsraGurdal et al (2004) Turkey	96.6	3.3	
SB Pai et al (2005) Bangalore	80	20	
Atthaporn et al (2009) Thailand	82	16	2
Sandhya et al (2013) Maharastra	90.1	9.8	
Janardhan et al (2017) Hyderabad	92.50	7.50	
Present study	100		

CHART20: Number of ACoA



b) COURSE OF ACoA:

Esra et al [14] (2004) observed out of 30 specimens, she observed one specimen with oblique ACoA which is around 3.3%.

SB Pai et al [42] (2005) observed out of the ten ACA complexes, he observed 90% of the specimens with transverse ACoA and 10% of the specimens with oblique ACoA.

Shwetha Kedia et al [25] (2013) observed out of 15 formalin fixed brains, ACoA was horizontal in 2 specimens (13.3%) and oblique in 13 specimens (86.6%)

In the present study, in 80% of the specimens, transverse ACoA was observed and in remaining 20% oblique ACoA was observed. The present study observation correlates with the results observed by SB Pai et al.

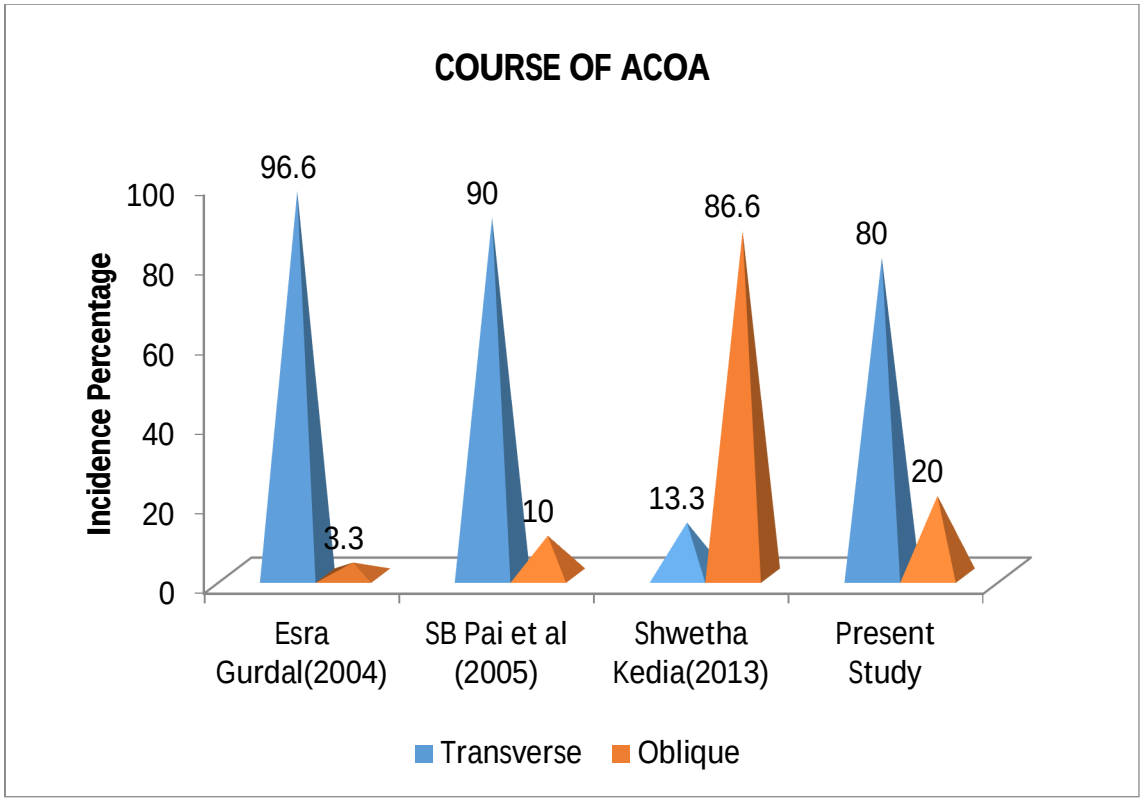
Except for the study conducted by Shwetha kedial et al all the above studies including the present study showed increased incidence of transverse ACoA than oblique ACoA.

The course of the ACoA has neurosurgical importance during exposure of the region for different purposes. Knowledge of these variations in the course of ACoA will increase the success of the procedure.

TABLE 20: Course of ACoA

Name of the study	Transverse (%)	Oblique (%)
Esra Gurdal(2004) Turkey	96.6	3.3
SB Pai et al (2005) Bangalore	90	10
Shwetha Kedia(2013) Chandigarh	13.3	86.6
Present Study	80	20

CHART 21: Course of ACoA



C) Length of AcoA

Lee Kc et al [28] (1981) observed the maximum length of ACoA was 3.4 mm, and the minimum length was 1mm. The mean Length of ACoA observed in his study was 1.73mm.

Sylvia Kamath et al [59] (1981) observed the maximum length of ACoA was 10.4mm and the minimum length was 0.5mm. The mean length of ACoA observed was 2.5mm.

Sandhya et al [55] (2013) observed the maximum length of ACoA was 9mm and the minimum length of ACoA was 1mm. The mean length of ACoA in their study was 3.3mm

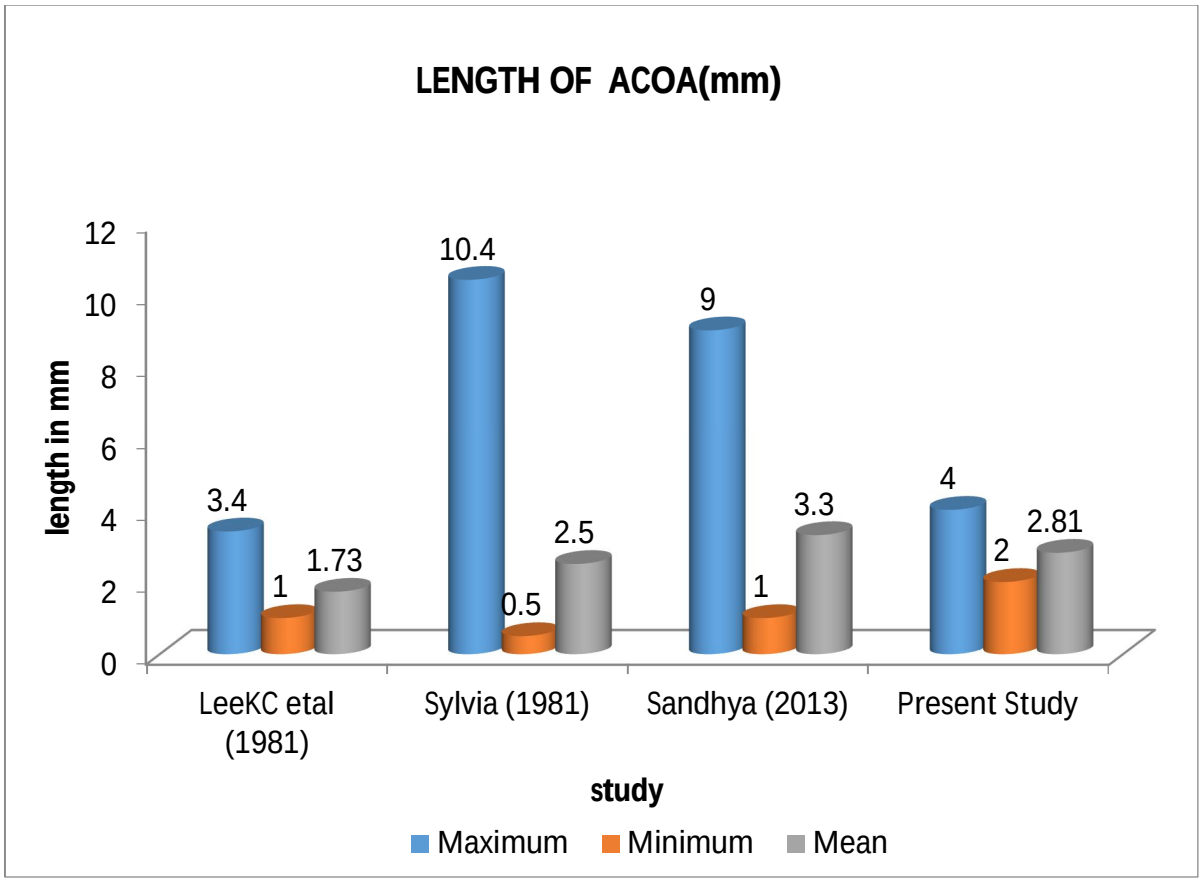
In the present study the maximum length of ACoA observed was 4 mm and the minimum length of ACoA observed was 2 mm. The mean length of ACoA observed was 2.81mm.

The mean length of ACoA observed in the present study coincides with the mean length observed in the study conducted by Sylvia Kamath et al in 1981.

TABLE 21: Length of ACOA (mm)

Name of the study	Maximum length in mm	Minimum length in mm	Mean length in mm
LeeKC et al (1981) Korea	3.4	1	1.73
Sylvia Kamath et al (1981)Bangalore	10.4	0.5	2.5
Sandhya et al (2013)Maharastra	9	1	3.3
Present Study	4	2	2.81

CHART 22: Length of ACoA (mm)



D) Diameter of ACoA (mm)

Sylvia Kamath et al [59] (1981) observed the maximum diameter of ACoA was 4.9mm. The minimum diameter of ACoA observed was 0.4mm. The mean diameter of ACoA observed in his study was 1.9mm.

Sandhya et al [55] (2013) observed the maximum diameter of ACoA as 4mm. The minimum diameter observed in her study was 1mm. The mean diameter of ACoA observed in her study was 2.4mm

Yuhui et al [65] (2015) observed the diameters of ACoA in 45 preserved brains. The maximum diameter of ACoA observed in his study was 3.9mm and the minimum diameter of ACoA observed in his study was 0.2mm. The mean diameter of ACoA in his study as 1.22mm

In the present study, the maximum diameter of ACoA observed was 3.07mm, the minimum diameter of the ACoA measured was 2.01mm. The mean diameter of the ACoA observed in the present study was 2.52mm.

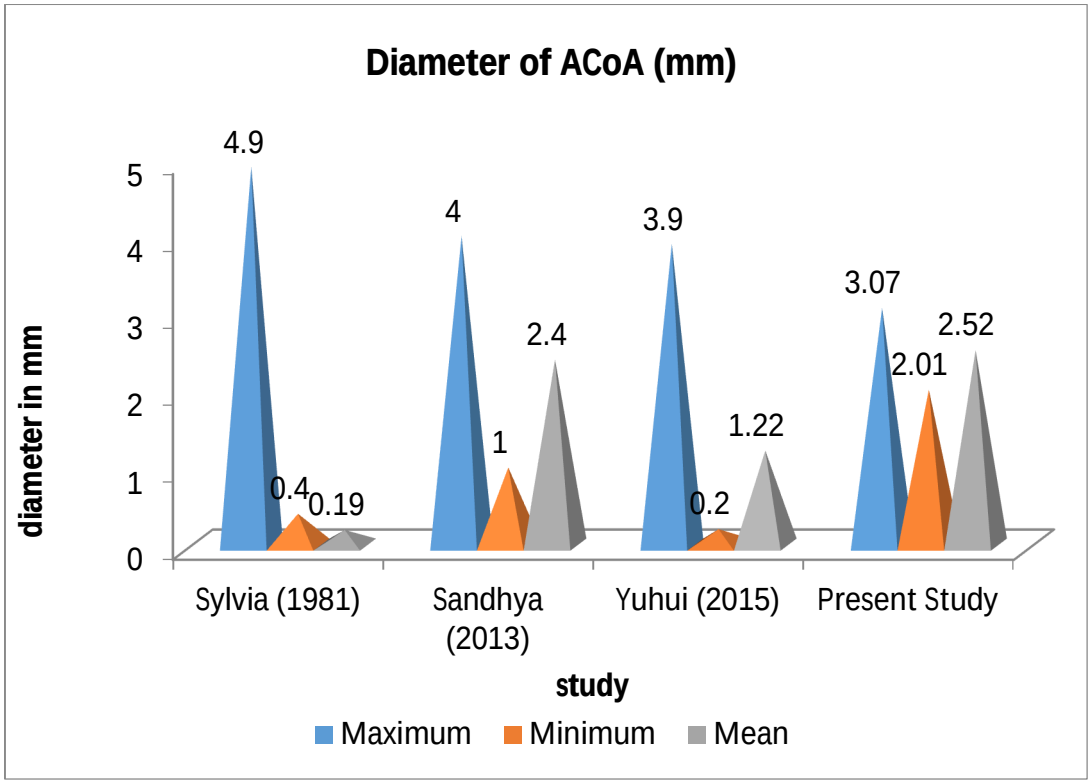
The mean diameter of ACoA observed in the present study correlates with the mean diameter of ACoA observed by Sandhya in 2013.

The incidence of fusiform aneurysms are more common in large diameter ACoA. The projection of aneurysmal fundus depends upon the course of ACoA. The length of ACoA is a significant determinant in the surgical management of ACoA aneurysms.

TABLE 22: Diameter of ACoA (mm)

Name of the study	Maximum diameter in mm	Minimum diameter in mm	Mean diameter in mm
Sylvia (1981)Bangalore	4.9	0.4	1.9
Sandhya (2013)Maharastra	4	1	2.4
Yuhui (2015) China	3.9	0.2	1.22
Present Study	3.07	2.01	2.52

CHART 23: Diameter of ACoA (mm)



V) ORIGIN OF RAH

Perlmutter Rhoton et al [45] (1976) observed the RAH in 78% of the specimens arose from the A2 segment, in 14% it arose from the A1 segment and in 8% it arose from the ACoA and ACA junction.

Lee Kc et al [28] (1981) observed in 65% of the specimens the RAH arose from the A2 segment, in 10% of the specimens it arose from the A1 segment and in 25% of the specimens it arose from the ACoA and ACA junction.

Gomes et al [19] (1984) observed RAH originated from the A2 segment of the ACA in 57% of the specimens, from the junction of ACA and ACoA in 35 % of the specimens, and from the A1 segment of the ACA in 8% of the specimens.

Aydin IH et al [7] (1994) he reported that out of 48 cases, in 58% RAH originated from the junction of A1 and A2 segment, in 23% from A2 segment of ACA & from A1 segment in 4%. It was symmetrically taking off in 13% and hypoplastic 2% of the cases.

Emel AVCI et al [12] (2003) observed that forty nine (64%) of the 77 RAHs arose from the A2 segment, 22 (29%) from the ACoA – ACA junction, and six (8%) from the A1 segment.

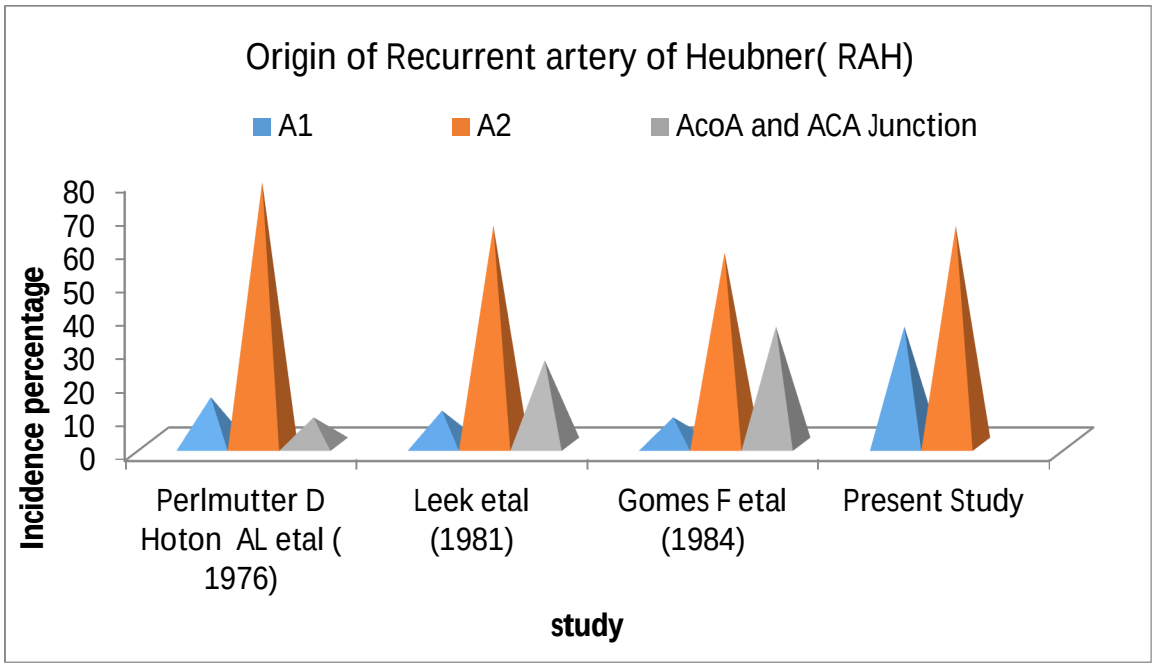
In the present study, RAH is seen to arise from the A2 segment in 65% of the specimens and from the A1 segment in 35% of the specimens.

The origin of Recurrent artery of Heubner from the A1 segment increases its exposure to injury during clipping of A1 segment of the ACA in the management of the ACoA aneurysms.

TABLE 23: Origin of Recurrent artery of Heubner(RAH)

Name of the study	From A1 segment of ACA (%)	From A2 segment of ACA (%)	From AcoA and ACA Junction (%)
Rhoton AL et al U S (1976)	14	78	8
Leekc et al Korea (1981)	10	65	25
Gomes F et al China (1984)	8	57	35
Present Study	35	65	-

CHART 24: Origin of Recurrent artery of Heubner(RAH)



VI) ORBITO FRONTAL ARTERY (OFA)

a) Origin

Ellie R. Lee and James D. Eastwood [11] (2000) have reported an unusual variant of the OFA arising from hypoplastic contralateral ACA A1 segment.

Atthaporn Boongbird et al [6] (2009) observed that in all the 100 brain hemispheres, Orbito Frontal Artery originated from the A2 segment, courses to the gyrate rectus, Olfactory tract and Olfactorybulb.

In the present study, in all the sixty hemispheres, OFA arose from the A2 segments of the ACA of the same side. This observation is similar to that of the study by Atthaporn in 2009

b) Distance of OFA from ACoA:

Stefani et al [57] (2000) observed the mean distance of origin of OFA from ACA & ACoA junction as 7.68 mm.

Emel AVCI et al [12] (2003) observed the OFA was consistently the smallest branch of ACA and always arose from the A2 segment of the ACA as a single trunk and ran to gyrate rectus, olfactory tract and olfactory bulb. The distance between the ACoA and OFA ranged from 2.61mm to 8.22mm. The average distance between the two observed in his study was 5.96mm.

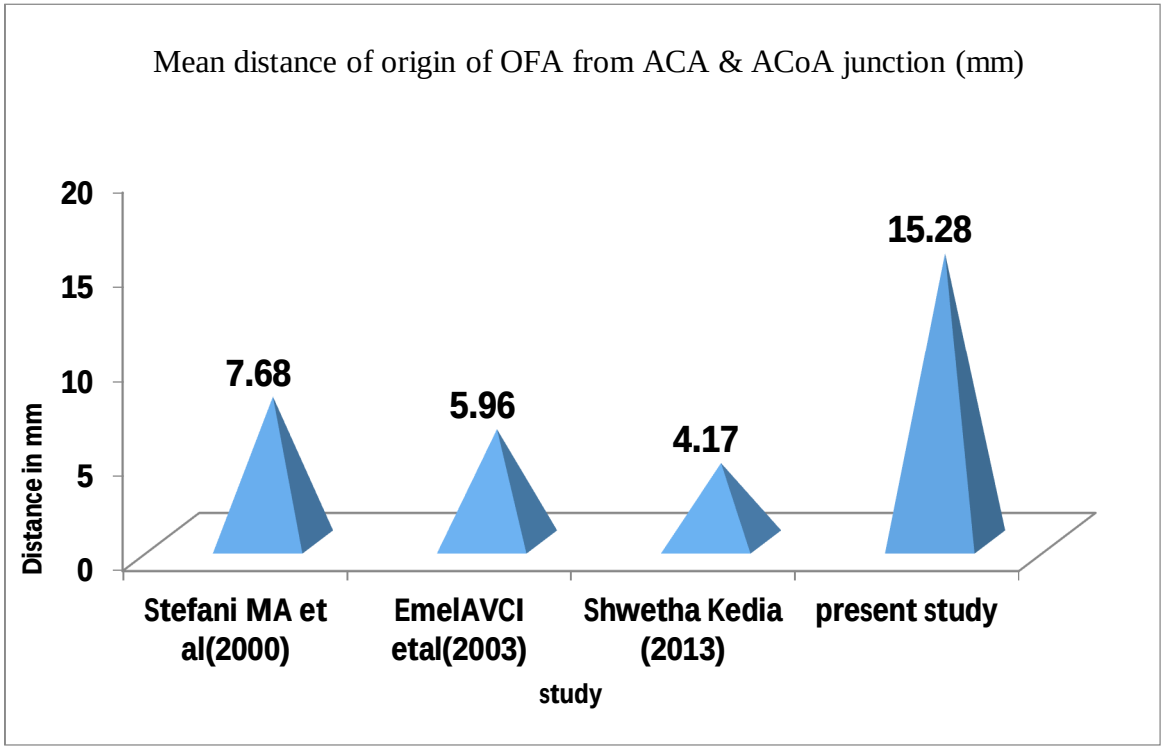
Shwetha Kedia et al [25] (2013) observed the mean distance of origin of OFA from ACA & ACoA junction as 4.17mm. She also observed that in almost

83.3% of the specimens OFA arose from the A2 segment of the Anterior Cerebral Artery.

TABLE24: Mean distance of origin of OFA from ACA & ACoA junction (mm)

Name of the study	Mean distance (mm)
Stefani et al West Bengal (2000)	7.68
EmelAVCI et al Turkey (2003)	5.96
Shwetha Kedia et al Chandigarh (2013)	4.17
present study	15.28

CHART 25: Mean distance of origin of OFA from ACA & ACoA junction (mm)



VII) Distance of FPA artery from ACoA:

Emel AVCI et al [12] (2003) observed that FPA arose from the A2 segment in 95% of the specimens and in other 5% it arose from the A3 segment of the ACA. The mean distance of origin of FPA from the ACA & ACoA junction observed in his study was 14.6mm.

Shwetha Kedia et al [25] (2013) observed the mean distance of origin of FPA from ACA & ACoA junction as 8.5mm. She also observed that in almost 40% of the specimens FPA arose from the A2 segment of the Anterior Cerebral Artery.

In the present study, the mean distance of origin of FPA from the junction between ACA & ACoA observed was 32.33 mm

The RAH, OFA and the FPA are three branches that arise from the ACA near the ACoA complex. Distinguishing these vessels is important since the consequences of injury or occlusion of the FPA and OFA are significantly less than that of the RAH.

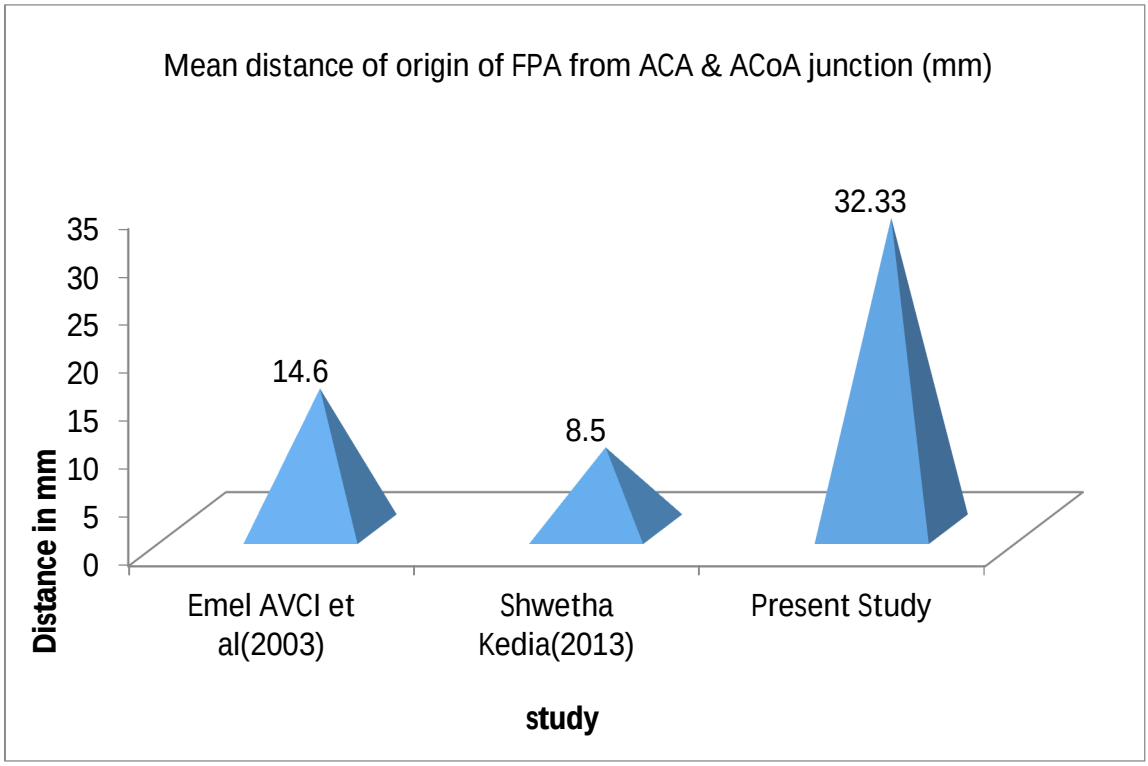
Moreover identification of the OFA and FPA is surgically important because in the management of ACoA aneurysms, small FPA and OFA may sometimes have to be sacrificed for clipping of the aneurysms, but the RAH should never intentionally be sacrificed.

The distance of origin of these branches from ACA & ACoA junction will be helpful to the neurosurgeons to locate the vessels exactly in microsurgery

TABLE 25: Mean distance of origin of FPA from the ACA & ACoA junction

Name of the study	Mean distance (mm)
Emel AVCI et al Turkey (2003)	14.6
Shwetha Kedia et al Chandigarh (2013)	8.5
Present Study	32.33

CHART 26: Mean distance of origin of FPA from ACA & ACoA junction (mm)



VIII) CALLOSO MARGINAL ARTERY (CMA)

a) Origin

SB Pai et al [42] (2002) observed the origin of Calloso Marginal Artery from the A2 segment in all the 20 hemispheres, at the genu of the corpus callosum after which the pericallosal artery would turn posteriorly.

Jun Yoshida et al [23] (2016) reported an unusual variant of Calloso Marginal Artery from the A1 segment of the left Anterior Cerebral Artery.

In the present study, in all the sixty hemispheres, CMA is seen to arise from the A2 segment of the ACA of the same side similar to the study of SB Pai in the year 2002.

b) Distance of origin of CMA from ACA & ACoA junction (mm)

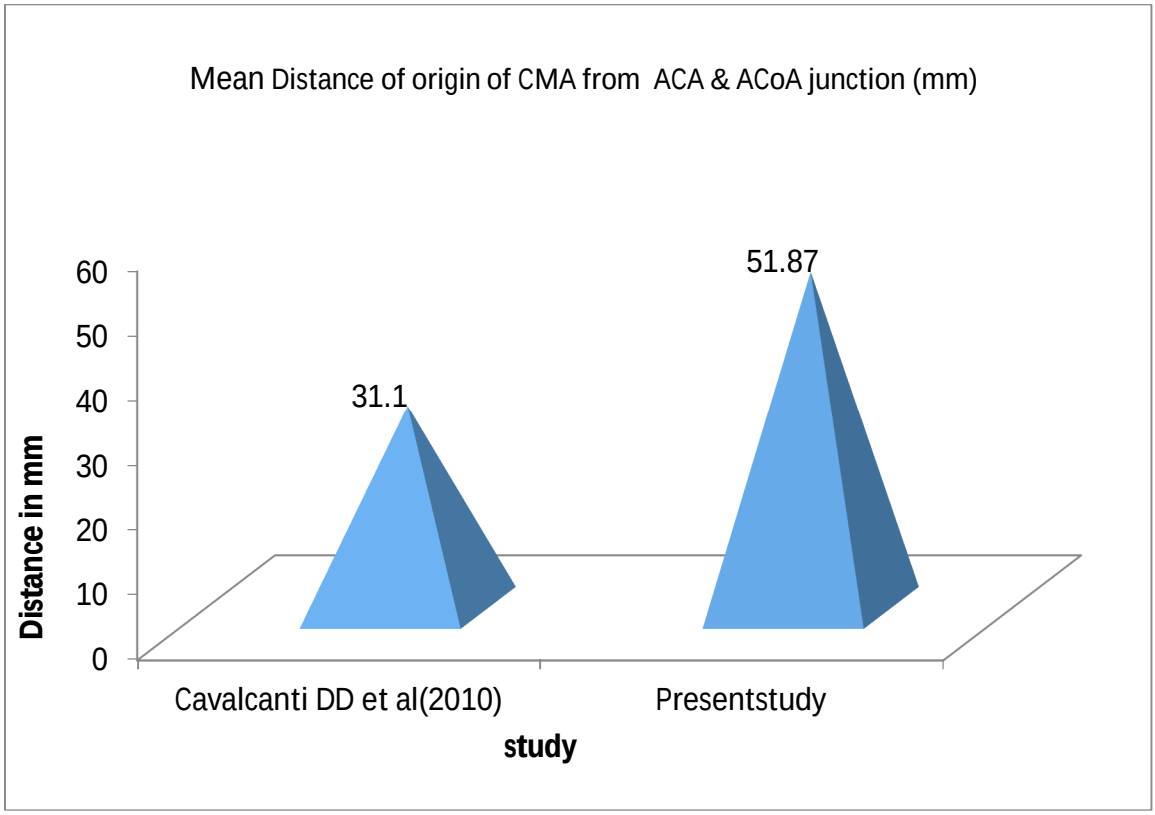
Cavalcanti DD et al [8] (2010) observed the mean distance of origin of CMA from the ACA & ACoA junction was 31.1mm

The average distance of origin of CMA from the ACA & ACoA junction in the present study was 51. 87 mm which was more than the average distance observed in the above study.

TABLE 26: Mean distance of origin of CMA from ACA & ACoA junction (mm)

Name of the study	Mean distance(mm)
Cavalcanti DD et al (2010)	31.1
Present study	51.87

CHART 27: Mean distance of origin of CMA from ACA & ACoA junction (mm)



The Knowledge on the the distance of origin of these branches from ACA & ACoA junction will be helpful to the neurosurgeons to locate the vessels exactly in microsurgery

Conclusion

CONCLUSION

The Anterior Cerebral Artery and Anterior Communicating Artery, were studied in detail by conventional dissection method.

The observations of the present study were compared with the findings of previous studies. The following conclusions were derived from this study.

- In all the 60 cerebral hemispheres, the origin of Anterior Cerebral Artery was from the Internal Carotid Artery of the same side.
- The ACA coursed the above optic nerve or optic chiasma in 59 hemispheres (98.3%). In 1 hemisphere, the artery coursed below the optic chiasma close to the optic nerve (1.67%).
- In all the 60 cerebral hemispheres, the A1 segment of the ACA was single. Agenesis, duplication or triplication of the A1 segment of the ACA was not observed in the present study.
- The length of A1 segment of right ACA in the present study ranged from 16 mm to 12 mm with an average of 13.70 mm. The length of A1 segment of left ACA ranged from 16 mm to 12 mm with an average of 14.43mm
- The average diameter of A1 segment of right ACA observed in the present study was 1.72mm ranged between 2.58 mm and 0.72 mm. The average

diameter of A1 segment of left ACA observed in the present study was 1.76mm ranged between 2.60 mm and 0.68 mm.

- In all the 30 specimens, Anterior Communicating Artery was single, duplication or triplication of the Anterior Communicating artery was not observed in the present study.

- The course of ACoA was oblique in 20% of specimens and transverse in 80% of specimens.

- The average length of ACoA was 2.81mm with a range from 4 mm to 2 mm.

- The average diameter of ACoA was 2.52 mm with the range from 3.07 mm to 2.01 mm.

- On the right side, the Recurrent Artery of Heubner originated from A1 segment in 33.3% of the specimens, from the A2 segment in 66.7% of the specimens. On the left side, the artery originated from the A2 segment in 63.7% and from the A1 segment in 36.7% of the specimens.

- The average distance of origin of orbitofrontal artery from ACoA & ACA junction was 14.20 mm on the right side and average distance on the left side was 16.37mm
- The average distance of origin of FPA from ACA & ACoA junction was 30.37 mm on the right side and 34.30 on the left side.

- The average distance of origin of CMA from ACA & ACoA junction was 49.87 mm on the right side and 53.87 mm on left side.

- The distance of origin of these branches from ACA & ACoA junction will be helpful to the neurosurgeons to locate the vessels exactly in microsurgery.

The relation of the artery to the Optic nerve gives us an idea about the location of compression in visual defects. In aneurysm of ACA with unequal diameter of both sides, the base of the aneurysm arises on the side of larger A1 and the dome points towards the side of the hypoplastic A1. Recurrent artery of Heubner, an important central artery of ACA should be preserved while clamping an aneurysm of ACA – ACoA complex.

The comprehensive study of the origin, course, length, diameter, branches and the distance of origin of branches of anterior cerebral artery and anterior communicating artery will be useful to the neurosurgeons for planning endovascular surgeries and anastomosing surgeries .It is also useful for radiologists to interpret various imaging of Anterior Cerebral Artery and Anterior Communicating Artery.

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MASTER CHART

SPECIMEN NO	ORIGIN OF ACA		RELATION OF THE ARTERY TO Op.N/Op.C		LENGTH OF A1(MM)		NO OF A1		DIAMETER OF A1(MM)		ANTERIOR COMMUNICATING ARTERY (ACoA)			
	LT	RT	RT	LT	RT (MM)	LT(MM)	RT	LT	RT	LT	NUMBER	COURSE	LENGTH	DIAMETER
1	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	14	SINGLE	SINGLE	1.69	1.68	SINGLE	TRANVERSE	2	2.01
2	LT ICA	RT ICA	Above the Op.C	Above the Op.C	15	15	SINGLE	SINGLE	1.71	0.98	SINGLE	TRANVERSE	3	2.32
3	LT ICA	RT ICA	Above the Op.N	Above the Op.N	12	12	SINGLE	SINGLE	1.45	1.39	SINGLE	OBLIQUE	3	2.2
4	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	15	SINGLE	SINGLE	2.01	2.09	SINGLE	TRANVERSE	4	2.34
5	LT ICA	RT ICA	Above the Op.N	Above the Op.N	12	13	SINGLE	SINGLE	1.66	1.78	SINGLE	TRANVERSE	3	2.5
6	LT ICA	RT ICA	Above the Op.N	Above the Op.N	13	14	SINGLE	SINGLE	2.25	2.47	SINGLE	TRANVERSE	3	2.34
7	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	15	SINGLE	SINGLE	2.1	2.41	SINGLE	TRANVERSE	3	2.56
8	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	15	SINGLE	SINGLE	2.58	2.6	SINGLE	OBLIQUE	2	2.01
9	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	15	SINGLE	SINGLE	1.28	1.47	SINGLE	OBLIQUE	2	2.09
10	LT ICA	RT ICA	Above the Op.N	Above the Op.N	12	13	SINGLE	SINGLE	1.34	0.68	SINGLE	OBLIQUE	3	2.87
11	LT ICA	RT ICA	Above the Op.N	Above the Op.N	13	15	SINGLE	SINGLE	2.24	2.2	SINGLE	OBLIQUE	4	2.7
12	LT ICA	RT ICA	Above the Op.C	Above the Op.C	14	13	SINGLE	SINGLE	1.67	1.8	SINGLE	OBLIQUE	2	2.75
13	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	15	SINGLE	SINGLE	1.48	1.37	SINGLE	OBLIQUE	2	2.2
14	LT ICA	RT ICA	Above the Op.N	Above the Op.N	13	14	SINGLE	SINGLE	2.07	2.12	SINGLE	OBLIQUE	2	2.15
15	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	15	SINGLE	SINGLE	0.72	2.39	SINGLE	OBLIQUE	2	2.3
16	LT ICA	RT ICA	Below the Op.C	Above the Op.C	13	14	SINGLE	SINGLE	1.74	1.78	SINGLE	OBLIQUE	2	2.12
17	LT ICA	RT ICA	Above the Op.N	Above the Op.N	13	14	SINGLE	SINGLE	1.75	1.67	SINGLE	OBLIQUE	3	2.09
18	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	15	SINGLE	SINGLE	1.74	1.69	SINGLE	OBLIQUE	2	2.87
19	LT ICA	RT ICA	Above the Op.C	Above the Op.C	14	15	SINGLE	SINGLE	1.65	1.59	SINGLE	OBLIQUE	2	2.9
20	LT ICA	RT ICA	Above the Op.N	Above the Op.N	12	13	SINGLE	SINGLE	1.5	1.67	SINGLE	OBLIQUE	3	2.92
21	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	14	SINGLE	SINGLE	1.69	1.71	SINGLE	OBLIQUE	3	2.93
22	LT ICA	RT ICA	Above the Op.C	Above the Op.C	14	14	SINGLE	SINGLE	2.01	2.09	SINGLE	OBLIQUE	3	2.6
23	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	15	SINGLE	SINGLE	1.68	1.59	SINGLE	OBLIQUE	3	2.59
24	LT ICA	RT ICA	Above the Op.N	Above the Op.N	16	16	SINGLE	SINGLE	1.72	1.7	SINGLE	OBLIQUE	3	2.98
25	LT ICA	RT ICA	Above the Op.C	Above the Op.C	13	15	SINGLE	SINGLE	1.59	1.54	SINGLE	OBLIQUE	3	3.07
26	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	14	SINGLE	SINGLE	1.47	1.51	SINGLE	OBLIQUE	3	2.9
27	LT ICA	RT ICA	Above the Op.N	Above the Op.N	13	14	SINGLE	SINGLE	1.67	1.69	SINGLE	OBLIQUE	4	3
28	LT ICA	RT ICA	Above the Op.C	Above the Op.C	16	16	SINGLE	SINGLE	1.72	1.69	SINGLE	OBLIQUE	4	2.12
29	LT ICA	RT ICA	Above the Op.N	Above the Op.N	15	16	SINGLE	SINGLE	1.69	1.6	SINGLE	OBLIQUE	3	2.85
30	LT ICA	RT ICA	Above the Op.N	Above the Op.N	14	15	SINGLE	SINGLE	1.78	1.74	SINGLE	OBLIQUE	3	2.24

SPECIMEN NO	ORIGIN OF RECURRENT ARTERY OF HEUBNER(RAH)		ORBITO-FRONTAL ARTERY(OFA)				FRONTO POLAR ARTERY(FPA)				CALLOSO MARGINAL ARTERY(CMA)			
			RT		LT		RT		LT		RT		LT	
	RT	LT	ORIGIN	DISTANCE	ORIGIN	DISTANCE	ORIGIN	DISTANCE	ORIGIN	DISTANCE	ORIGIN	DISTANCE	ORIGIN	DISTANCE
1	A2	A2	A2	20	A2	18	A2	42	A2	38	A2	63	A2	58
2	A2	A2	A2	22	A2	23	A2	46	A2	47	A2	64	A2	66
3	A2	A2	A2	21	A2	22	A2	44	A2	47	A2	60	A2	62
4	A1	A1	A2	19	A2	20	A2	39	A2	41	A2	56	A2	59
5	A2	A2	A2	17	A2	18	A2	36	A2	37	A2	53	A2	55
6	A2	A1	A2	12	A2	11	A2	26	A2	23	A2	46	A2	44
7	A2	A2	A2	11	A2	12	A2	23	A2	26	A2	41	A2	47
8	A2	A2	A2	12	A2	13	A2	26	A2	28	A2	48	A2	53
9	A1	A1	A2	14	A2	15	A2	29	A2	31	A2	49	A2	51
10	A2	A2	A2	20	A2	24	A2	42	A2	46	A2	64	A2	66
11	A1	A1	A2	16	A2	18	A2	34	A2	39	A2	51	A2	56
12	A2	A2	A2	19	A2	19	A2	41	A2	43	A2	61	A2	63
13	A1	A1	A2	18	A2	22	A2	37	A2	46	A2	55	A2	58
14	A2	A2	A2	14	A2	17	A2	34	A2	36	A2	51	A2	56
15	A2	A2	A2	11	A2	17	A2	24	A2	29	A2	46	A2	51
16	A2	A2	A2	13	A2	15	A2	29	A2	33	A2	50	A2	53
17	A2	A2	A2	12	A2	16	A2	26	A2	34	A2	47	A2	56
18	A2	A2	A2	12	A2	15	A2	27	A2	36	A2	49	A2	54
19	A1	A1	A2	10	A2	12	A2	23	A2	27	A2	39	A2	44
20	A2	A2	A2	15	A2	17	A2	31	A2	35	A2	49	A2	54
21	A2	A2	A2	10	A2	14	A2	22	A2	30	A2	39	A2	51
22	A2	A2	A2	12	A2	14	A2	26	A2	29	A2	54	A2	57
23	A1	A1	A2	11	A2	14	A2	23	A2	29	A2	42	A2	49
24	A2	A2	A2	15	A2	17	A2	33	A2	37	A2	51	A2	56
25	A1	A1	A2	13	A2	16	A2	27	A2	36	A2	49	A2	52
26	A2	A2	A2	12	A2	15	A2	25	A2	31	A2	43	A2	47
27	A1	A1	A2	11	A2	14	A2	24	A2	30	A2	44	A2	50
28	A2	A2	A2	13	A2	15	A2	27	A2	31	A2	48	A2	52
29	A1	A1	A2	10	A2	13	A2	21	A2	27	A2	37	A2	46
30	A1	A1	A2	11	A2	15	A2	24	A2	27	A2	47	A2	50

KEYS TO MASTER CHART

ACA	-	Anterior Cerebral Artery
ACoA	-	Anterior Communicating Artery
ICA	-	Internal Carotid Artery
RAH	-	Recurrent Artery of Heubner
CMA	-	Calloso Marginal Artery
OFA	-	Orbito Frontal Artery
FPA	-	Fronto Polar Artery
OP.N	-	Optic Nerve
OP.C	-	Optic Chiasma
RT	-	Right
LT	-	Left